BULLETIN OF THE
SCHOOL OF EDUCATION
INDIANA UNIVERSITY

Vol. III BLOOMINGTON, INDIANA No. 6

JULY, 1927

Entered as second-class mail matter September 30, 1924, at the postoffice at Bloomington, Indiana, under the Act of August 24, 1912. Published six times a year from the University Office, Bloomington, Indiana.

Fourteenth Annual Conference on Educational Measurements

Held at Indiana University
April 15 and 16, 1927

EDUCATION READING ROOM
2 HR RESERVE

Bureau of Coöperative Research, Indiana University School of Education

HENRY LESTER SMITH, Director

INDIANA UNIVERSITY
EDUCATION
READING ROOM

Price, 50 cents. For sale by the University Bookstore, Bloomington, Ind.

A limited number of copies of this bulletin will be distributed free of charge to citizens of Indiana.

BULLETIN OF THE SCHOOL OF EDUCATION, INDIANA UNIVERSITY

Fourteenth Annual Conference

on

Educational Measurements

Held at Indiana University
April 15 and 16, 1927

INDIANA UNIVERSITY
EDUCATION
READING ROOM

Published by the
BUREAU OF COÖPERATIVE RESEARCH
INDIANA UNIVERSITY

Contents

PAGE

A PROPOSED MARKING SYSTEM FOR COLLEGES AND UNIVERSITIES
Grover T. Somers, Associate Professor of Education, Indiana University.. 3

INDIVIDUAL DIFFERENCES IN METHODS OF INTELLECTUAL WORK
Charles H. Judd, Professor and Head of the Department of Education, University of Chicago..... 23

A BRIEF SUMMARY OF THE ESSENTIAL FACTS CONCERNING THE PURPOSE, HISTORY, AND WORK OF THE BUREAU OF COÖPERATIVE RESEARCH AT INDIANA UNIVERSITY
H. L. Smith, Dean of the School of Education and Director of the Bureau of Coöperative Research, Indiana University..... 31

STUDIES IN GRADE PLACEMENT
Charles H. Judd..... 34

AN EXPERIMENT IN THE CONTENT OF HIGH SCHOOL PHYSICS
Carl G. F. Franzén, Professor of Secondary Education, Indiana University 42

SOCIAL PSYCHOLOGY AS A BASIS FOR EDUCATIONAL PSYCHOLOGY
Charles H. Judd..... 58

A Proposed Marking System for Colleges and Universities

GROVER T. SOMERS, Associate Professor of Education, Indiana University

No System of Marking at Present. That we have no marking system, worthy of the name system, at present, in our college and university work is apparent to everyone who is connected with these institutions either as members of the faculty or as students. We may each have our own pet practice but we have no real system either individually or collectively. The results of this condition make for injustice to students, discomfort to our own selves, and chaos to the records of the institution.

That we have a real problem to bring about something that scents of order and system needs no proof to anyone who has inspected the records in the office of the registrar with respect to the distribution of "marks" (or grades) turned in by different members, either in the same or different departments, of the faculty during the same term or those reported by the same instructor at different times, during different terms. A sample illustration or two will suffice to call to our attention something of the conditions obtaining in representative state universities in both academic and professional courses, by experienced and inexperienced instructors alike.

We might briefly cite the results from two representative universities in the Middle West and make our comparison on the basis of credit points—counting "A"=3, "B"=2, "C"=1, "D"=0, "E"=0—making one semester hour the basal unit for this particular purpose. It is hardly necessary to go into great detail; the facts are so clear they speak for themselves. The glaring contrasts tell their own story and any comments we might add would in large part be unnecessary and superfluous.

A casual inspection of the facts presented in Table I will reveal a partial picture at least of the conditions prevailing. It may readily be seen that marking conditions are closely similar in the two institutions whether considered from the point of view of departments and subjects or from that of individual instructors in the same or different departments and courses.

In selecting the facts from these two institutions no attempt was made to pick *solitary* extreme cases to typify the status of things. On the other hand, we endeavored to choose representative cases, high and low, and average them, and only those departments or instructors in which or under whom there was a fairly large group of students, fifty or more. This is what was done in every case where it was possible—where more than one instructor *existed* in the particular department or subject considered.

TABLE I.—"MARKING" CONDITIONS FOUND IN TYPICAL INSTITUTIONS, 1924-25, BY CREDIT POINTS

	I. University A (average 1.41)			II. University B (average 1.49)
1.	*By Departments—*			
	General Subjects			
	Chemistry, Mathematics, and Physics	0.86	1.28	Geology, Chemistry, and Mathematics
	Zoölogy, Anatomy, and Physiology	1.82	1.82	Physical Education, Botany, and Hygiene
	Highly Selective			
	Bacteriology	0.92	1.00	Astronomy
	Ancient Language	1.82	2.16	Latin
	Career Motive			
	Law	1.35	1.11	Law
	Journalism and Animal Industry	2.06	1.90	Journalism
2.	*By Instructors—*			
	General Subjects			
	Chemistry, Mathematics, and Physics (average 3 instructors)	0.72	0.79	English, Chemistry, and Mathematics (average 3 instructors)
	English, Zoölogy, and Anatomy (average 3 instructors)	1.86	2.17	Physical Education, Botany, and Physics (average 3 instructors)
	Highly Selective			
	Bacteriology (1 instructor)	0.92	0.96	German and Astronomy
	Ancient Language (1 instructor)	1.82	2.36	Political Science and Latin (average 2 instructors)
	Career Motive			
	Law (average 2 instructors)	1.24	0.84	Law (average 2 instructors)
	Journalism, Animal Industry, and Mines (average 3 instructors)	2.26	2.31	Journalism, Commercial Subjects, and Music (average 3 instructors)
	Average Differences	1.02	1.42	
	General Average Differences	.92	1.12	

Running thru the table we find differences between representatives of the "high and low" order of approximately 1 credit point on the average, one full step on the marking or grading scale. This is true for different subjects generally—those which have a *general appeal* (widely selected), those which have a *narrow appeal* (highly selective), and those which have a *definite life appeal* (career motive).

Present Status of Marking. The situation as it now stands might be briefly summed up in the following way, somewhat in this form:

1. Different teachers "give" the same mark for unlike and unequal performance and attainment.
2. Different teachers "give" different marks for the same or equivalent performance and attainment.
3. The same teacher "gives" different marks for the same or equivalent performance or achievement. (Friend X "gave" *Miss Unattractiveness* a "D" for a copy—exact duplicate—of a unit of work for which he had given *Miss Attractiveness* an "A"!)
4. The same teacher "gives" the same mark for unlike or unequal performance or achievement.
5. The upshot and result of it all is that "marks" have little or no definite meaning or significance. The same mark may—and frequently does—mean very different things with different teachers and by no means the same thing to the same teacher at different times and with respect to the performance or achievement of different "subjects."
6. The "personal equation" frequently becomes a highly magnified factor in our "gifts." Beautiful bodies, kind souls, and attractive personalities are too often subtle influences playing upon the gratuity of the donor. And "marks" come to reflect in a very real sense our estimate of the person as a whole and our attitude toward him (or her) as well as our estimate of his performance in a particular field or in a certain part of it.

Why these wide differences? Poor selection and good selection of students? Nature of the subjects taught? Or differences in methods and techniques and personality of instructors? Or perhaps general effectiveness or ineffectiveness of the instructors *per se*?

Effect on Instructors and Students. As co-laborers we are inclined to stand in awe of a teacher who possesses so masterful a technique or so much power otherwise as to be able to lift his students so very much higher on the scale than the average of us and wish (if we dare not hope!) that we might somehow sip from the same fountain and get a taste at least of the elixir of magnificent accomplishment. And toward the teacher who is so ineffective or "hard-boiled" we have the proper amount of pity or fear as the nature of his case may require or justify.

Students are keenly awake to these facts of differences in requirements and markings. Whatever we think of their lack of alertness in our courses from time to time, they are not slow to discover who are unduly severe and who are generously lax in grading and marking, nor are they slow to act accordingly. The result is they "pick" certain

courses and certain teachers with a hopeful expectation of rich rewards and at the same time shun other teachers and avoid other courses to insure against disappointments when the reckoning day comes round and the final records are filed. At times students even shut themselves off from interesting and valuable courses because of the reputation of the department or instructor for large exactions of work and application and penurious marking.

Purpose of Marking. What, we might ask, is the purpose of marking anyhow? Why not, as many contend, mark simply *passed* or *failed*? Why emphasize the question of levels or degrees? For our present purpose the answer might well be because efficiency is generally understood to mean "qantity and quality of work accomplished within a given amount of time," and "marks" are a means of expressing or indicating the quantity and quality side of things.

The purpose involved in marking seems to be at least threefold: (1) to express the status of the student's achievement; (2) to measure the teacher's effectiveness; and (3) to indicate the desirable next steps on the part of either the teacher or student or both.

To realize this purpose it follows that it is essential that there be a reasonable equalization and standardization with respect to the records of an institution and that there be a reasonable reliability and consistency with respect to the marks of the same and different instructors at different times with the same or different student groups. This is quite necessary if proper appeals are to be made as to the purpose of measurement: the picturing of their levels of achievement, the justice and fairness of "ratings" made, and the basis for subsequent action—the desirable next step in their educational performances.

Purposes and Principles. The function of an institution, be it arts and science curriculum or professional, is to equip its students with certain informations, techniques, skills, attitudes, and ideals considered essential to success in the various fields of activity into which they go.

The function of the instructor is to contribute a certain portion of these qualities and of this equipment to the final product, and his labors must be so directed and expended as to produce maximum results with a minimum of effort and time on the part of both teacher and student.

To this end he must know the goal and the means of reaching it, the objectives and the processes and materials essential thereunto. He must know not only what he is aiming to attain, but in what direction he is traveling and how fast he is moving in that direction. He must know the final standard to be required and the level of accomplishment at stated periods, and the ways and means of passing from the temporary to the final level.

Measurement is therefore necessary; tests must be employed to determine the status of the student's attainment and the teacher's efficiency. These should serve to guide the teacher from time to time in judging effort and application, evaluating techniques and methods, and assessing the student's achievement and final placement. It is not our purpose to suggest kinds of measurements to be made or types of tests

to be employed—merely to point to the fact (as it is) that some sort must be given. And whatever be given the results obtained must be treated and evaluated and expressed in an intelligible and acceptable and serviceable form.

While the intelligibility and acceptability of resulting expressions may be related to or even dependent upon the character of our measurements, resulting in turn from testing done, yet that is essentially another and a different problem—certainly not our primary, or even necessary, present concern. Whatever the measurements and however obtained, the treatment given them and the final expression of them will be one and the same—the assessment of the student's reactions and the teacher's efforts and the placement of achievement at designated levels.

Problems of Marking. The problem of marking, educationally considered, is no simple matter. The mathematics of it (involved) may be a rather elementary process—probably fifth or sixth grade arithmetic should be the upper limit necessary. Instead of one single simple *problem* there are at least three somewhat complex *problems*—as related to (1) the teacher, (2) the institution, and (3) the student.

As to the teacher: He is confronted with the problem of determining (1) a reasonably fair mark for the particular student on a certain piece of work or performance; (2) reasonably equitable marks for other students on the same piece of work whose performance may be equivalent or different; and (3) reasonably fair and just marks for the same student on different pieces of work and for equivalent or different performances.

As to the institution: It is faced with the problem of (1) interpreting intelligibly the various marks of the same instructor or the "same" marks of different instructors; (2) reducing to a common denominator all marks of the same or like "denominations"; and (3) insuring an equitable distribution of marks by different instructors with the same or equivalent student personnel.

As to the student: He is constantly faced with the problem of (1) ascertaining the *level of performance* or achievement in a particular course or in various courses; (2) evaluating his performance or achievement in terms of that of his fellows and on the institutional scale; and (3) realizing points of weakness and educational needs, as well as points of strength and educational attainment, so as to know and be able to take the desirable next steps.

These problems are by no means unrelated nor mutually exclusive. Rather the reverse. They are in many respects closely related and even interdependent. The solution of the one renders the others less difficult of solution. What helps us over one of these helps us over the other two in a very real sense. Any method we might propose or adopt for the one would have a certain value for the others.

A Disclaimer. In the nature of the problem widely different things cannot be rendered the same, alike, or even equivalent by any known process. No hope is here entertained that all marks of the same denomination determined by the method we propose will stand for exactly

the same grade of performance or the same identical level of achievement. The factors involved are too numerous and the resulting product too complex to warrant one in hoping for (expecting) more than a reasonable approximation to equivalence.

Teachers of the same subject, as well as those of different subjects, employ different methods and techniques, emphasize and stress different points and values, activate different drives and responses, and develop different attitudes and ambitions. Students apply themselves differently for different teachers and in different educational environments with outcomes differing in both character and amount (magnitude). Means of measurement have not yet reached a state of infallibility either in character or in comprehensiveness, and obtained results are still in an imperfect state.

But given all these varied factors our problem is how not only to avoid intensifying these admitted differences but even to reduce them to minimal proportions and to make them, in so far as may be, inoperative in their effect. We are primarily concerned with keeping the error as small as possible since it is obviously impossible to correct for it to the point of perfect elimination. Our job is to take the measurements presented and so treat them and interpret them and transmute them fairly into letter or per cent marks. Errors there may, and will, be in the scores themselves, and what measurements are entirely free from inaccuracies and imperfections? Such errors we cannot prevent, but taken as they are, our purpose is to treat them so that further gross errors may be avoided.

Not the Only Scheme. Several schemes for determining "marks" have been proposed during the past few years, some of which have great merit from various points of view, but time does not permit a description or a discussion of any one of them. They are in print, either in books or in journals, and available, and I shall assume an acquaintance with them now or in the future on the part of those who may be especially interested. The time allotted me will be devoted to a discussion of the features and use of this particular one. This, I should like to insist, is not the only one which offers help in our situation, altho I believe it has some merit not possessed by any other scheme with which I am familiar.

The test of any proposed scheme, plan, system, method, technique, or what not in education today is: *Does it work?* If it really works it possesses value. And its merit is in proportion to the service it renders toward the attainment of certain desirable objectives. If the system we are proposing will assist us in reaching certain of our educational ends we may at least find some justification for considering these points in some detail, and making the scheme as clear as possible so that any one who may be interested in giving it a trial in his own institution to see in how far it really will work will be in a position to do so. More than a trial is neither justified nor desired.

Need of Standard Procedure. If our content tests and examinations were standardized or the various units of work or performance properly

evaluated and appraised, there would be no especial need, much less a necessity, for proposing any particular scheme of "marking." If we knew what constitutes an "A," "B," "C," or "D" level of performance or achievement we could easily dispose of the question. At most our tests and examinations as generally constructed and applied are but relative measures—relative to the particular group we happen to be teaching and testing. If an expected amount of "A's" and "B's" result, it may be termed "*fairly fair*"; if an unexpectedly large number of "A's" and "B's" result we may speak of it as being "*fairly easy*"; and if a disappointingly small number of "A's" and "B's" are found we have reasons for calling it "*fairly hard*." That is, assuming that we have estimated *fairly* accurately the ability of our group.

If, however, our estimate of the group be inaccurate—either too high or too low—the test so considered would not necessarily be "fair," "too easy," or "too hard." If we are teaching a superior group a comparatively large number of high "marks" should be won and awarded, and if we are teaching an inferior group the reverse would be found true—a relatively small number of high "marks" with a correspondingly large number of low "marks."

Every teacher, not possessing the power of divination, has his disappointments and surprises from time to time and particularly in connection with testing. Not infrequently we are prone to infer, on the face of our test and examination results, that our students have learned surprisingly much, or disappointingly little. It may be that we too frequently attribute the cause to superior teaching on our part, or inferior, as the case may be. If we may reasonably assume that teachers generally do not vary much in their instructional effectiveness from term to term or from year to year this seeming "up-ness and down-ness" in our curve of results is probably due largely to our over-sensitive measuring instruments. And we have so far employed no reasonable, not to say scientific, correction for properly evaluating the results thus obtained. It is this correction that we have in mind, a means of determining a fair distribution of "course marks" and at the same time a just evaluation of the student's achievement.

Assumptions in "Marking" under the Proposed Scheme. In the system or scheme we have to propose the following assumptions are made. That some of them will not stand as 100 per cent sound will be obvious at the outset.

1. "Mark" is a relative term; whereas "score" is an absolute term, and the former is derived from the latter by a process of equating.
2. In our marking schemes (A, B, C, D, E, or per cents of 100, 90, 80, 70, etc.) differences in steps are approximately equal.
3. Group of average ability should do average work and should receive average rewards, and a group of above or below average ability should do correspondingly above or below average work and should receive corresponding rewards.
4. Scores and measurements made are reasonably reliable whether they result from the traditional test, personal estimate, or the more ob-

jective type of measurement. The *scores* fairly represent achievement made, expressed quantitatively.

5. Approximately equal effectiveness of teaching, by the same instructor with different groups or different instructors with the same or equivalent groups, is assumed.
6. Ability of the group is distributed and the course scores are likewise distributed, but neither need be distributed normally. Possible to get at some reasonable measure of the spread such as quartiles or standard deviation.

The Proposed Plan (Scheme or System). From the discussion of the question so far it may be readily inferred that the essential purpose of the plan (or system) is to harmonize and systematize "marks" with instructors individually and collectively and to standardize them on the basis of brains, to recognize the quality of the student material as a central factor in determining the quality or level of achievement.

It is, therefore, necessary that we make both "ability measurements" and "achievement measurements" of the student population. We need to know the levels and distribution of mental ability inherent in the group as a whole for purposes of determining and fixing standards initially and for making comparisons of particular individual groups later. We need to know what proportion of the student body (or what part of each class) belongs respectively to the "A," "B," "C," "D," and "E" ability levels if such be in harmony with the step scheme of marking. The same principle applies to the per cent or other scales in use.

That is to say, a "Standard Key" (see pages 14 and 19) is derived or constructed on the basis of mental ability measures (Raw Scores, Mental Age, Percentiles, Intelligence Quotients, et cetera) in harmony with the marking scheme (letter or per cents) in use, this for the entire institution, or divisions or classes in the institution, preferably the former so as to make Freshmen, Sophomores, Juniors, and Seniors strictly comparable (see Chart No. 3). And once the "Key" is set up for the institution as a whole it serves as a reference measure for the individual instructor's problems from time to time in determining and distributing marks for any particular group or for different groups.

If the group be typical of the entire student population, having the "normal" proportion of the several ability levels represented, the problem is fairly simple and easily disposed of. He need only divide the base line of the distribution of course scores into five approximately equal parts and assign marks accordingly. But if the group be not strictly typical of the whole student body, either above or below, then he must equate for this difference and determine the equivalent levels. He must know not only what level of performance is represented by the median or average of the particular group considered but also how far up or down the scale to go to set the limits of the various steps or stages or levels.

A simple method is described and illustrated in Cases I(a) and II (pp. 12 and 19) and further illustrated and applied (pages 15 and 16) to groups somewhat above and below average in ability and with tests

relatively easy or difficult. (See pages 15 and 16.) The distribution (Case Ia) for both ability measures and test scores is fairly symmetrical and normal, and the group itself is fairly representative of the student body, only slightly above the average. The resulting distribution should be fairly obvious; the proportion for each of the five steps or levels will be approximately the same as that for levels of ability represented in the entire student population.

If, however, the range and distribution of course scores differs widely from the range and distribution of mental ability measures the proper or resulting distribution of marks is not so obvious. Or, if the particular group concerned is above or below the average in ability the same would hold; we cannot assign proper marks offhand. It would be difficult, if not impossible, to decide at a glance what proportion of marks of each denomination will (or should) result. To determine this we must compare the variability of course scores with the variability of ability measures and section the distribution of course scores accordingly and proportionally.

And a quick, simple, and easy method of equating and relating to standards is described on page 14 in connection with plotting the diagonal and reading scores as letter grades. It becomes essentially a matter of proportional triangles on the one hand and of reading equivalents of numbers obtained (translating) into "marks" as per the "Standard Key." That is to say, if the average or median ability of the group is at the "B" level, the average or median course score should yield a "B" mark and other scores should yield relatively and proportionately high marks. If, however, the average or median ability of the group is at the "D" level, the average or median course score should yield a "D" mark with other scores yielding relatively and proportionately low marks. And so on for any other ability group. This is precisely what results from the treatment indicated.

A further sample is shown (Case II) on page 19, drawn from experience during the first semester of the present session. It represents two sections in the same course measured in the same way for both ability and achievement. Thurstone Intelligence Test IV scores were used for the former and certain course test scores for the latter. (As a matter of fact the course test scores were divided by three in each case to reduce the arithmetic, to avoid large numbers.) Tentative "Ability Standards" are indicated together with a "Key in Ability-Like Numbers" and the resulting "marks" from the application of this scheme to the facts of the case.

It will be noted that three individuals who had a course score of 64, and who received a mark of "C," differed somewhat in mental ability ratings—41 per cent, 53 per cent, 64 per cent (expressed in percentiles). Of the two with a course score of 79 and term mark of "A," their ability ratings were 76 per cent and 96 per cent. And of the two with a course score of 54 and a term mark of "D," their mental ability ratings were 18 per cent and 47 per cent (when expressed in percentiles). The level of ability of any particular student may be high, low, or average, without affecting directly his mark in the course.

Distribution of the I.Q's. and the Test Scores from the Highest to the Lowest in Steps of Three, Counting the Number in each Case the Mid-Point of the Interval

CASE I(a) (NORMAL GROUP)

Distribution	Frequency	Sum of Frequency	I.Q.	Test Score	Sum of Frequency	Frequency	Distribution
**	1	143	145	80	143	2	**
	0	142	142	77	141	2	**
	0	142	139	74	139	1	*
*	1	142	136	71	138	4	****
**	2	141	133	68	134	6	******
**	2	139	130	65	128	7	*******
****	4	137	127	62	121	3	***
******	6	133	124	59	118	7	*******
******	6	127	121	56	111	10	**********Q_3
**********	10	121	118	53	101	19	**********
Q_3**********	11	111	115	50	82	13	**********M
**********	16	100	112	47	69	13	**********
**********	18	84	109	44	56	6	******
**********	18	66	106	41	50	16	**********Q_1
Q_1**********	13	48	103	38	34	8	********
**********	17	35	100	35	266	8	********
*******	7	18	97	32	18	4	****
****	4	11	94	29	14	5	*****
***	3	7	91	26	9	3	***
**	2	4	88	23	6	3	***
**	2	2	85	20	3	1	*
				17	2	1	*
				14	2	0	
				11	1	1	*

Symbols and Formulae:

N = Number of Cases 143

$$M = \text{Median Score} \ldots \frac{N+1}{2} = \text{Point where 72d score from lowest falls.}$$

$$Q_1 = 25 \text{ Percentile} \ldots \frac{N+1}{4} = \text{Point where 36th score from lowest falls.}$$

$$Q_3 = 75 \text{ Percentile} \ldots \frac{3(N+1)}{4} = \text{Point where 107th score from lowest falls.}$$

Steps in the procedure:

1. Arrange the I.Q's. from high to low on left side of page.
2. Likewise for the Test Scores on the right side of page.
3. Compute Q_1, Median, and Q_3 of the I.Q's.
4. Likewise for Q_1, Median, and Q_3 of the Test Scores.
5. Locate these points along each margin as indicated above.

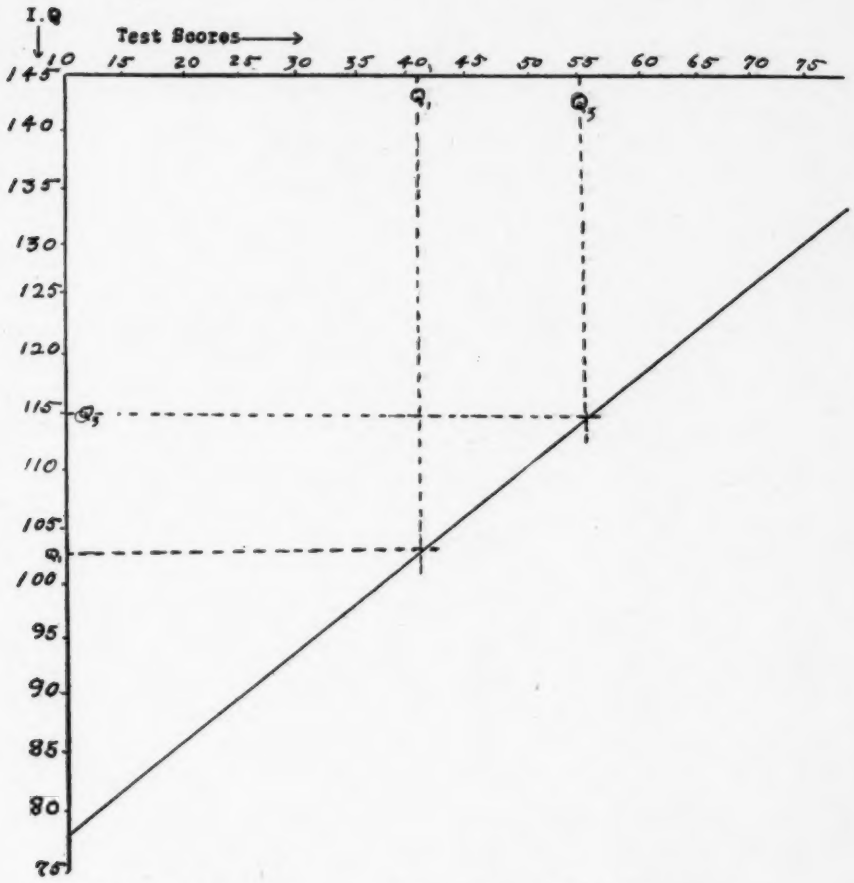


CHART 1—CONSTRUCTION OF THE DIAGRAM (TO FIT OBTAINED RESULTS).

Based on proportional variability of ability measures and content scores of the middle 50 per cent of the group. Any other relatively stable part of the group—the middle 68 per cent, between minus 1σ and plus 1σ for example —would serve the same purpose. Scores within these limits represent the achievement of the group ability within the same limits whether high, low, or in-between, and these ability-like-numbers referred to the standard key will yield the achievement mark.

TRANSMUTATION OF TEST SCORES INTO LETTER MARKS (GRADES)

Plotting the diagonal:

1. From Q_1 in test scores drop a perpendicular.
2. From Q_1 in I.Q's draw a line to the right intersecting this perpendicular.
3. From Q_3 in test scores drop another perpendicular.
4. From Q_3 in I.Q's draw a line to the right intersecting this perpendicular.
5. Draw a straight line thru these two points of intersection and extend it to the lines of scores and I.Q's. This is the required diagonal.

Reading scores as letter grades:

1. Find the number from left to right (Chart 1) corresponding to the student's score.
2. Then drop straight down to the diagonal and then sharply over to the corresponding I.Q., on the left.
3. The position of this I.Q.-like-number in the key below will give the letter grade for the student on your class roll.

Key in I.Q.-like-numbers:

A = 125 and up.
B = 115 to 124.
C = 105 to 114.
D = 95 to 104.
E = 94 and less.

For Example:

1. Score of 57 in Tests (Case I(a)) drops to diagonal (Chart 1) at the level of approximately 117 I.Q. which reads in the *Key* (immediately above) a "B" grade.
2. Score of 30 in Tests drops likewise to the diagonal at the level of 93-94 I.Q. which reads in the *Key* an "E" grade.
3. Score of 52 in Tests in like manner yields a grade of "C."
4. And so on for any score in Tests.

CASE I(b) (WEAK GROUP)

Distribution	Frequency	Sum of Frequency	I.Q.	Test Score	Sum of Frequency	Frequency	Distribution
*	1	143	130	68	143	2	**
	0	142	127	65	141	2	**
	0	142	124	62	139	1	*
*	1	142	121	59	138	4	****
**	2	141	118	56	134	6	******
**	2	139	115	53	128	7	*******
****	4	137	112	50	121	3	***
******	6	133	109	47	118	7	*******
******	6	127	106	44	111	10	**********Q_3
**********	10	121	103	41	101	19	**********
Q_2**********	11	111	100	38	82	13	**********
**********	16	100	97	35	69	13	**********M
M**********	18	84	94	32	56	6	******
**********	18	66	91	29	50	16	**********Q_1
Q_1**********	13	48	88	26	34	8	********
**********	17	35	85	23	26	8	********
*******	7	18	82	20	18	4	****
****	4	11	79	17	14	5	*****
***	3	7	76	14	9	3	***
**	2	4	73	11	6	3	***
**	2	2	70	8	3	1	*
				5	2	2	**

CASE I(c) (STRONG GROUP)

Distribution	Frequency	Sum of Frequency	I.Q.	Test Score	Sum of Frequency	Frequency	Distribution
*	1	143	160	92	143	2	**
	0	142	157	89	141	2	**
	0	142	154	86	139	1	*
*	1	142	151	83	138	4	****
**	2	141	148	80	134	6	******
**	2	139	145	77	128	7	*******
****	4	137	142	74	121	3	***
******	6	133	139	71	118	7	*******
******	6	127	136	68	111	10	**********Q_3
**********	10	121	133	65	101	19	**********
Q_2**********	11	111	130	62	82	13	**********
**********	16	100	127	59	69	13	**********M
M**********	18	84	124	56	56	6	******
**********	18	66	121	53	50	16	**********Q_1
Q_1**********	13	48	118	50	34	8	********
**********	17	35	115	47	26	8	********
*******	7	18	112	44	18	4	****
****	4	11	109	41	14	5	*****
***	3	7	106	38	9	3	***
**	2	4	103	35	6	3	***
**	2	2	100	32	3	1	*
				29	2	1	*
				26	1	0	
				23	1	1	*

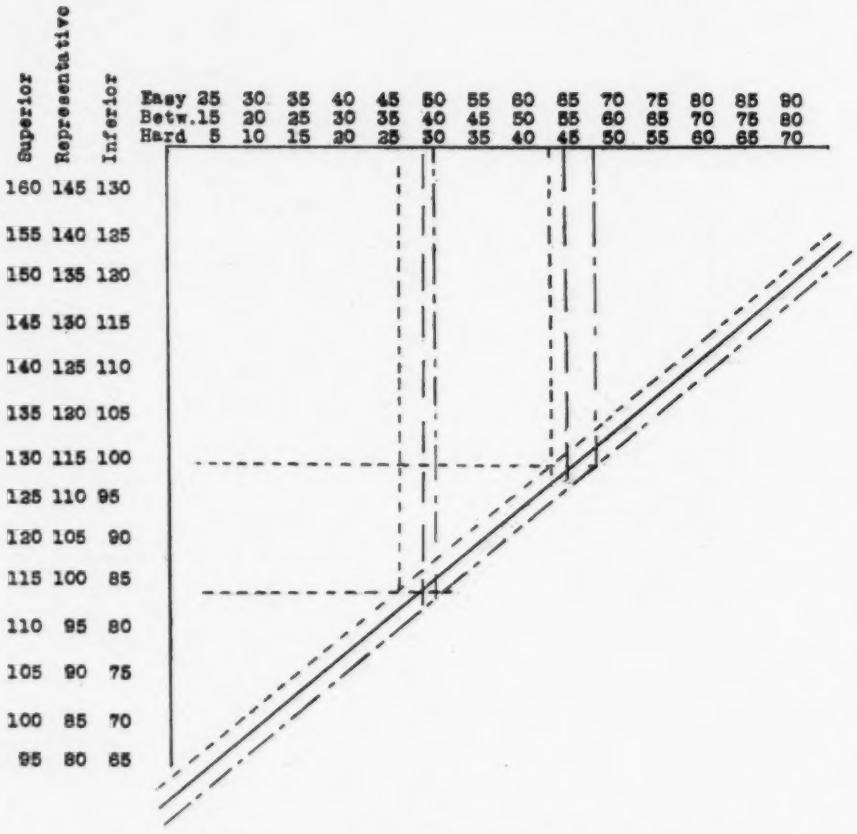


CHART 2—KEY DIAGRAM FOR DETERMINING MARK

When considered from any one of the three points of view:

(*a*) Superior group taking hard, average, or easy test.
(*b*) Representative group taking hard, average, or easy test.
(*c*) Inferior group taking hard, average, or easy test.

The mark depends solely upon the level of attainment that he succeeds in reaching. Doubtless his ability is a conditioning factor and it may set the limits of his possibilities but it has no direct and material relationship to the term mark. His ability rating, along with the ratings of all others in the group, is used simply to determine the ability of the group and the character of the distribution. Place any particular individual in any one of several ability groups in any course and his term mark will be the same, practically identically so, in every situation. This scheme yields the same results for him without exception. (See Chart 2, page 16.)

The arrangement in Charts 4 and 5 is based upon the assumption that the course scores reasonably and fairly represent or reflect the achievement of the group. Had the group been composed of brighter and more capable students it is reasonable to believe they would have made proportionately higher scores on the course. And it is equally reasonable to believe a less capable group would have made proportionately lower scores in the same course.

And when the median or average ability represented in this group is slightly (or somewhat) above the average or median for the entire student body it is but reasonable to think that the average score should yield a "mark" equally as far above the *average* "mark." The "mark" so yielded will (may) be obtained by referring the ability corresponding to the score to the "Standard Key." That is, take any student's score (average or otherwise) and drop straight down to the diagonal and then straight over to the left to find the ability measure corresponding, and that number referred to the "Key" will yield the mark in every case. For sample readings see foot of Chart 5.

Some Effects of the System. In the first place, it results in rewarding student achievement in terms of performance of ability groups. Any person regardless of his own capacity for accomplishment wins recognition for what he actually achieves and in proportion to the level of his achievement. If he does as well or as much as is accomplished normally by an "A ability group" his reward is an "A"; and if he does as well as a "B ability group" his reward is a "B"; and if he does only as well as a "C ability group" his reward is a "C," and so on regardless of his own ability level or rating. All in all, justice is done the student in question and in a reasonably full measure.

Moreover, the student can determine his own placement if given the facts in the case—his record score and the scheme or method of determining marks from them. The system is subject to treatment by formula the application of which is by no means difficult or elusive. And students when given the opportunity are eager to see how they come out and abide by the results surprisingly agreeably.

In the second place, teachers are spared a lot of annoyance and are freed from considerable embarrassment at times. We suffer no little disturbance occasionally concerning the proper "placement" of certain students. It is no easy matter sometimes to decide as between failure and passing or between a "B" or an "A," or a "B" or a "C." And when we are asked to justify the placement made it becomes exceedingly

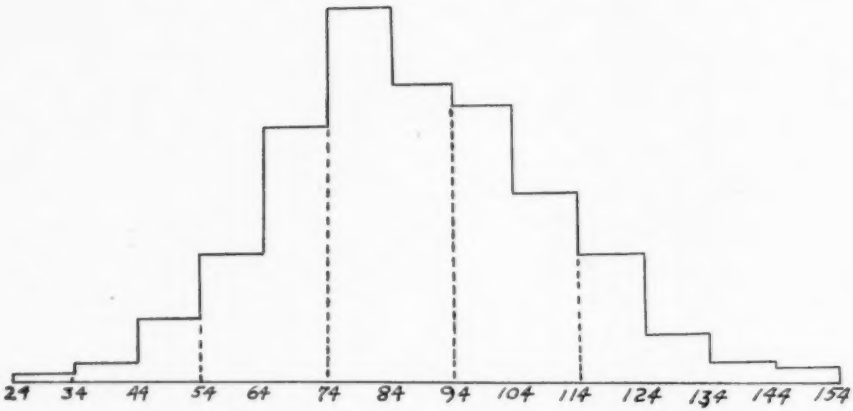


CHART 3—DISTRIBUTION OF MENTAL ABILITY (THURSTONE TEST)

Ability Groups ("Key")

Scale	Scores	Percents
A =	115 +	= 12
B =	95 — 114	= 26
C =	75 — 94	= 37
D =	55 — 74	= 20
E =	54 —	= 5

NOTE—The above groups together with a *Standard Key* are determined from the distribution of Mental Ability Scores for the entire institution on the basis of the results from the Thurstone Psychological Test IV. Only tentative or approximate standards can be suggested until further investigations have been carried thru.

CASE II

Distribution	Frequency	Sum of Frequency	Ability Score	Test Score	Sum of Frequency	Frequency	Distribution
*	1	72	145-150	83-84	72	2	**
**	2	71	139-144	81-82	70	1	*
**	2	69	133-138	79-80	69	2	**
***	3	67	127-132	77-78	67	5	*****
***	3	64	121-126	75-76	62	2	**
****	4	61	115-120	73-74	60	4	****
Q_3****	4	57	109-114	71-72	56	7	*******Q_3
*****	5	53	105-108	69-70	49	8	********
******	6	48	97-102	67-68	41	5	*****
M********	8	42	91- 96	65-66	36	7	*******M
*******	7	34	85- 90	63-64	29	4	****
*****	5	27	79- 84	61-62	25	3	***
Q_1*******	7	22	73- 78	59-60	22	4	****Q_1
*****	5	15	67- 72	57-58	18	5	*****
****	4	10	61- 66	55-56	13	5	*****
***	3	6	55- 60	53-54	8	1	*
**	2	3	49- 54	51-52	7	2	**
	0	1	43- 48	49-50	5	1	*
	0	1	37- 42	47-48	4	1	*
*	1	1	31- 36	45-46	3	1	*
	0	0	25- 30	43-44	2	2	**

Standard Ability

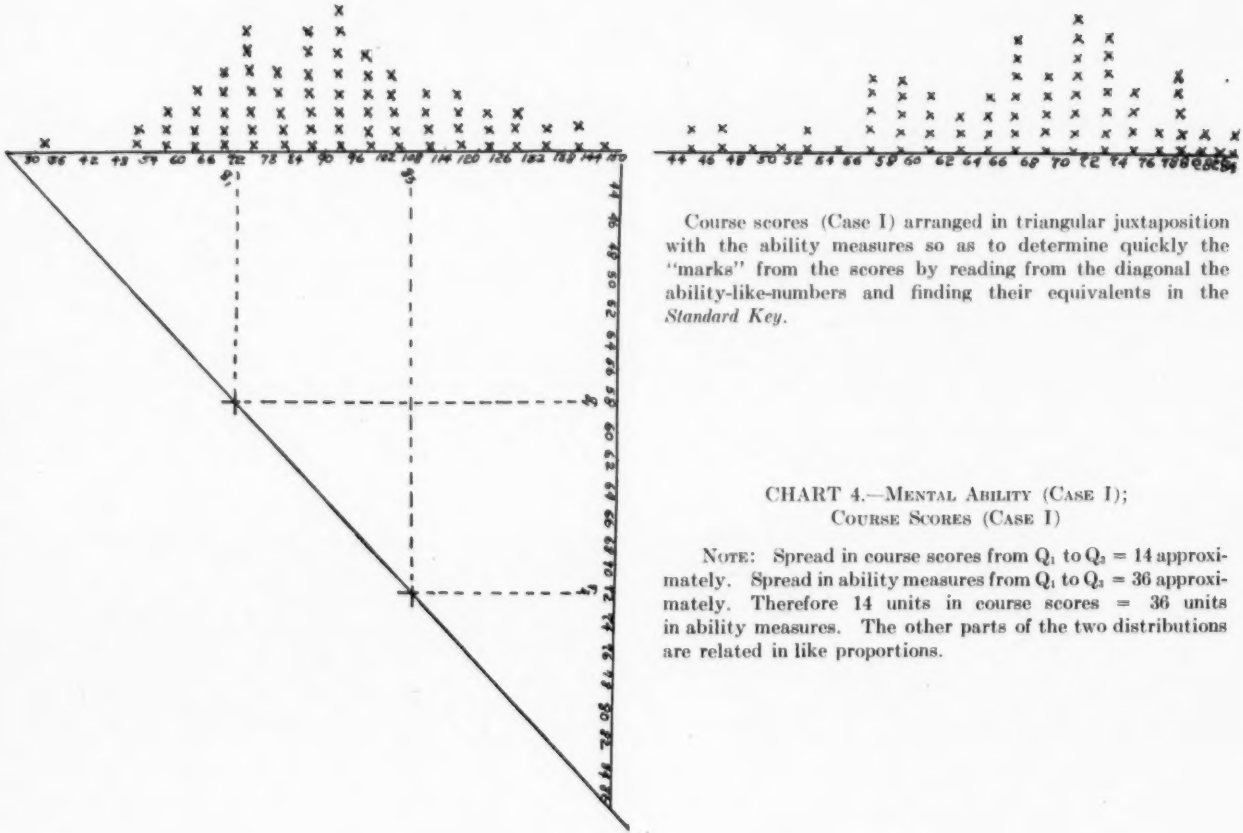
A —12 per cent (Approx.)
B —26 per cent (Approx.)
C —37 per cent (Approx.)
D —20 per cent (Approx.)
E — 5 per cent (Approx.)

Key in Ability-Like-Numbers

A —115 and above
B —95 to 114
C —75 to 94
D —55 to 74
E —54 and below

		Resulting Marks		Number	Per cent
75 and above	—	A	—	12	16.7
67 to 74	—	B	—	24	33.3
59 to 66	—	C	—	18	25.0
51 to 58	—	D	—	13	18.0
50 and below	—	E	—	5	7.0

4—41140



Course scores (Case I) arranged in triangular juxtaposition with the ability measures so as to determine quickly the "marks" from the scores by reading from the diagonal the ability-like-numbers and finding their equivalents in the *Standard Key*.

CHART 4.—Mental Ability (Case I); Course Scores (Case I)

Note: Spread in course scores from Q_1 to Q_3 = 14 approximately. Spread in ability measures from Q_1 to Q_3 = 36 approximately. Therefore 14 units in course scores = 36 units in ability measures. The other parts of the two distributions are related in like proportions.

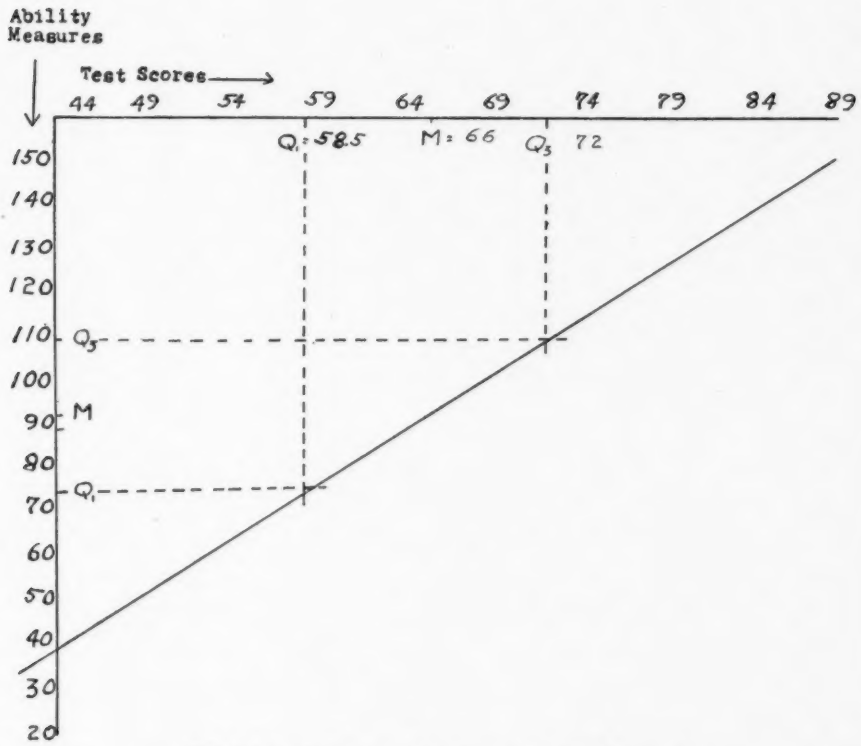


CHART 5—DIAGRAM TO FIT OBTAINED TEST RESULTS

Sample readings:

1. Score of 64 gives a 90 ability-like-number. This by the Key yields a mark of "C."
2. Score of 79 gives a 130 ability-like-number. This by the Key yields a mark of "A."
3. Score of 54 gives a 64 ability-like-number. This by the Key yields a mark of "D."

difficult. It becomes a matter chiefly of subjective judgment, and the pleasing personality and pretty face all too frequently get the prized placements and high marks and they know how to use their appeals. In this scheme pulchritude and winsomeness are not the only—not even the principal—virtues rewarded! Consistency becomes a virtue of the instructor. He marks equivalent performances the same and repeatedly so. (Friend X to whom we have already referred explains later to Miss Attractiveness of senior standing the *why* of her "C": *"Hawsie, you are pretty and I like you lots! But we aren't giving marks this year! We're having all the students earn them!"* . . . She had received an "A" for each of three years prior to this in his subject.)

In the third place, and finally, the records of the institution come to have a certain definite meaning and intelligibility. An "A" means that grade of performance ordinarily achieved by about ten or fifteen per cent of our superior ability students or the equivalent of such achievement. An "A ability" person applying himself reasonably well and effectively attains to such levels of performance, or one with less capacity who compensates sufficiently for the lack of ability by more arduous and longer application and by more effective methods may achieve equally as much.

And if all teachers use the same reasonably sound method, then each mark of a certain denomination ("A" for example) stands for approximately the same thing, and an "A" in one course is therefore closely equivalent to an "A" in any other course. A "B" in one course or from a certain instructor is likewise equivalent to a "B" in any other course or from any other instructor. And so on thruout the list or range of marks in our entire grading system.

We may thus hope to replace disorder and chaos by a reasonable degree of system and order to the satisfaction of both students and teachers and for the general intellectual and moral well-being of the institution as a whole. Not only a wish but also a hope if adopted and applied carefully and to the point.

Individual Differences in Methods of Intellectual Work

CHARLES H. JUDD, Professor and Head of the Department of Education, University of Chicago

The main facts with regard to individual differences are so well known that they require no lengthy restatement here. Pupils in the fourth grade show a range in their mastery of spelling and reading and arithmetic which reaches from the standards appropriate to the first grade to those appropriate to the eighth grade. Pupils of high general intelligence and pupils of low general intelligence come to the same school from the same community and even from the same family.

The individual differences which modern educational studies have shown to be present in every school must be taken into account when one attempts to arrange the materials which are to be used in teaching. Slow pupils and pupils of low general intelligence cannot assimilate ideas in the same way that bright pupils can. Pupils from one kind of homes have interests and insights which are absent from the experiences of pupils who come from other kinds of homes.

So profoundly have some educators been impressed by considerations like the foregoing that they have suggested an abandonment of the conventional type of school organization in favor of a new way of conducting instruction. There are ardent advocates of a most extreme type of what is known as individual teaching. These people argue that the existence of marked individual differences among pupils dictates a policy of strictly individual assignment of school tasks. The child who is able to progress rapidly in arithmetic should be allowed to go as rapidly as he can. He should not be held back to the slow pace of his classmates.

I have made reference to these familiar facts and to these arguments which have been advanced in favor of new types of teaching in order to prepare the background for the presentation of a much less radical view on this topic which I believe to be of great importance to school administrators. I shall attempt to persuade you in the comments which I shall make that individual differences are in no small measure products of teaching rather than natural traits of pupils. I shall offer some examples of acquired individual differences which should be avoided rather than tolerated. I shall describe other examples of individual differences which arise from the adoption by particular pupils of the best methods of intellectual procedure. In short, I shall argue that individual differences of certain types are undesirable and individual differences of another type are highly desirable.

Let us turn at once to some concrete cases. Professor Buswell has found in examining the way in which pupils add columns of figures

that there are very marked individual differences. Some pupils hunt up and down the column for combinations which will make ten. If a four appears at the top of the column a pupil of this type runs his eye down the column looking for a six or for two threes. If he finds the desired number he comes back once more to the top of the column and takes the second number. Suppose this is seven. Once more he looks down the line of figures trying to find a three. Professor Buswell has shown that this is a clumsy method of adding a column of figures. In the first place, it takes more time than does systematic addition, and, in the second place, it is full of hazards. Pupils very often become confused and lose their places in the column with the result that they use the same number twice or they omit one of the numbers.

Such a case as that described in the foregoing paragraph must not be thought of as an exhibition of general mental dullness. The pupil who hunts for tens is not doing something unnatural. On the contrary, it is certainly very natural for a bright child who sees that addition is a combination of units of a lower order into units of a higher order to adopt early the habit of looking for tens. Once the habit is well established in the simple examples encountered early in arithmetic, what is more natural than that it should be carried over into column addition?

The conditions are especially favorable in arithmetic for the development of purely private methods of procedure. The processes of addition which pupils perform are strictly private. They are not known to teachers and consequently are not checked in any way. The teachers in whose classes Professor Buswell worked were astonished to find how their pupils were proceeding. Very frequently these teachers found in the peculiar habits of individual pupils explanations of difficulties which they were aware existed but which they did not understand.

I wish by such an illustration as that which I have described to create in your minds a receptive attitude for the statement that rapid and efficient mental processes are very often due to good methods of intellectual work and that slow and inefficient mental operations are often to be explained as results of bad methods.

Let me use another illustration. Professor Gray found in the field of reading a case not unlike that just described in addition. Professor Gray's case was that of a boy who was adjudged incompetent to go on with fourth grade work because he could not read. This boy did not know that one ought to go systematically along a line from left to right in order to see all the words in their proper succession. His improper method of looking at a line of printed matter was to wander back and forth within the line picking up the meaning if possible from words recognized in irregular and relatively incoherent order.

It seems to those of us who know how to read a line of printed words very astonishing that anyone should fail to cultivate the right habit in this matter. The boy in question was, however, not at all a dull boy. The explanation of his case is that he did not learn to read in the early grades when the other pupils were acquiring that art. In

the early grades he learned the stories by heart while others were reading them. When he was called on to read he held the book in his hand but recited the words from memory. It made no difference to him where he looked on the page. After some years of this kind of irregular attention to words on printed pages, he came to grief at that stage in school work where one cannot any longer secure from others the knowledge of printed lines necessary for one's lessons.

The striking fact about the boy whom I have just described is that he was about to be excluded from school as an incompetent pupil. He was about to be classified as a defective. He was defective, but not in the ordinarily accepted meaning of that term. He was defective in his method of reading and his incompetency in this respect threw him out of contact with all of his lessons.

One more example of a type similar to those which I have cited may be drawn from the high school. A girl was reported by her instructors as unable to keep up with the class. She was apparently earnest and willing to work, but she could not get her lessons. Investigation showed that this girl was a slow, incompetent reader. She had been so thoroly drilled in the elementary school in oral reading that she carried into the upper school the idea that she must pronounce every word to herself in order to read properly. She was led by her elementary training and by her conscientiousness to follow a method of reading which was so slow that she could not cover the ground prescribed by her high school teachers. The girl was suffering from an inappropriate emphasis on oral reading when she should have been reading by the rapid and economical methods of silent reading.

The cases which I have cited could be paralleled by hundred of others where mental incompetency is to be explained by bad methods of intellectual work.

Let us turn now to some examples which show how mental activity can be facilitated by the adoption of right intellectual methods. It is a well-established finding of the psychological laboratory that if one wants to learn a poem of ten stanzas by heart, it is economical of time and effort to read thru the whole poem again and again without stopping rather than to commit to memory succeeding lines. "Whole learning" as it is called as distinguished from "part learning" is the best method.

Part learning which careful measurements have shown to be uneconomical from every point of view is the natural method. If a pupil is told to commit a poem to memory the most natural procedure for him to adopt is the studious repetition of a line at a time until he has it in mind and can repeat it. There is something very satisfying and tangible about the mastery of a line at a time. The method seems to be right but it is not. A moment's consideration will show why it is not right. By repeating a single line over and over a fixed association is established between the end of a line and its own beginning. The really desirable association is between the end of the first line and the beginning of the second line. Whole learning is the proper device for securing this second or proper association.

The lesson which is to be drawn from this discussion of whole and

part learning is a lesson of very general import. The pupil who learns to read his lessons thru without pause, the reader who knows enough to read a paragraph thru without stopping to worry over puzzling individual sentences will gain great advantage from the adoption of the whole method of study.

A second example which will reinforce the conclusion which I am trying to persuade you to adopt can be borrowed from the industrial world. In a certain foundry the workmen were shoveling coke, coal, and scrap iron with shovels which were all of the same size. The company had been in the habit of purchasing a certain stock size of shovel for their foundry. An efficiency engineer came into the foundry and noticed that the workmen were wasting time getting a proper load of the different materials on their shovels. The shovel was too large for scrap iron and too small for coke. The efficiency engineer induced the company to purchase three sizes of shovels and thereby effected an economy of 20 per cent in the work of the concern.

I have used this case of industrial economy because it represents, first of all, an accomplished fact, and, second, a very tangible and measurable result. I turn to the pedagogical parallel with the reservation that the outcome of the adjustment which I am about to describe is much less tangible and the adoption of the adjustment is far from an accomplished fact.

We know by scientific studies that reading is a very complicated process. Reading problems in arithmetic is not the same as reading narrative prose or reading a compact argument. The whole attitude of the reader is different in the different cases described. Reading of prose narrative is fluent and consists for a trained reader in a succession of recognitions of long phrases. Reading of a compact argument is relatively much slower. The phrases apprehended are shorter, showing that interpretation is much more labored. Reading should be adapted to various kinds of materials no less than shovels should be adapted to the materials which they are used to carry. When one reads narrative prose made up of familiar words where the ideas flow in coherent, easily mastered sequences requiring very little intellectual effort on the part of the reader, the process is of a type which reflects its light demand on the reader's thinking and discrimination. Reading a problem in arithmetic involves two very different kinds of attention. The verbal part of the problem, or what we may call the narrative part of the problem, can be read in large units. The moment the reader comes to the numbers which are included in the statement of the problem, reading must of necessity be of a wholly different type. Numbers have to be read minutely and with the highest degree of discriminative analysis. The teacher who assumes that reading is reading in all cases and fails to understand that reading arithmetic is different from reading narrative prose does not properly evaluate methods of intellectual procedure. In practical school experience the narrative part of arithmetic problems is often wholly neglected. The number part of problems is usually read at least twice and often more frequently because the first reading is not sufficiently detailed.

What I am trying to say is that teaching is not merely or chiefly a matter of allowing pupils to go on in school in an unsystematic fashion building up habits of work without guidance. Teaching, if it is effective in the highest degree, cultivates in the pupil proper and economical methods of intellectual procedure.

Let me mention without attempting to elaborate them certain other cases of good intellectual methods. A speaker can present his case well or clumsily. In the English class teachers try to teach methods of effective presentation. Another example is seen in the fact that one can keep accounts systematically and uniformly or one can have a badly arranged account book. Again one can play a musical instrument with proper methods of movement or one can blunder in his manipulations. At a more elementary level one may adopt correct modes of use of the vernacular or one can violate the established forms of vernacular expression.

If I have succeeded in any degree in making clear the principle for which I have been arguing, you will be prepared to take the next step toward which my argument has been leading.

All of the school subjects are in fact schemes of intellectual procedure. When the pupil studies geography he is learning methods of arranging a world which is made up of manifold relations which can be comprehended only when some kind of system is put behind all these relations. The four cardinal points represent a method of thinking clearly in the midst of the most manifold space world. The outlines presented in maps represent vast areas of land which can be thought of compactly and easily because the geographers have devised a way of representing them in symbolic form. Trade routes are reduced to lines, and the typical products of countries are reduced to pictures which can be retained with a minimum of intellectual effort. The science of geography is nothing but a method of assembling a vast array of confusing facts and making these facts readily comprehensible.

What has been said about geography can be said in like terms for each and every subject taught in the schools. History arranges in systematic order the doings of men and nations. Nature-study tells in systematic form of the development of plants and animals. Grammar tells of language, geometry of space, and so on.

It is a fair definition of education to say that it consists in a process of training pupils in the most economical and advantageous methods of thinking about the world and of dealing with the world.

What is the difference between a civilized group of people and an uncivilized group? The anthropologists tell us that all of the evidence goes to show that the most primitive tribes have natural ability of a high order. What they lack is methods and materials of thinking. The primitive savage has no geography except the limited knowledge of his immediate environment. He has no breadth of view. He is not a mental defective. He is merely an untrained individual.

There can be no doubt whatsoever that there are in every American community individuals who are ranked as humble members of society who have natural capacity for much higher types of performance than

those in which they are now engaged. Intelligence is not merely a matter of native possibility; it is quite as much a matter of training and achievement in desirable methods of thinking and behaving.

The consequences for practical school procedure of the doctrine which I have been advocating seem to me to be very large. If individual characteristics are in any measure the products of intellectual methods, then it is the duty of the school to pay a great deal of attention to these methods. Education is not a matter of passing pupils thru a certain series of opportunities but is rather a matter of guiding them so that they will adopt advantageous methods of operation. The teacher must constantly be on the alert to detect the way in which pupils do their work. Whenever the teacher observes a pupil doing something which is intellectually uneconomical, it is the teacher's duty to interpose some kind of corrective influence. Whenever the teacher observes a pupil progressing in the direction of an advantageous intelectual method, it is the teacher's duty to supply vigorous encouragement.

A recognition of all the school subjects as methods of thinking rather than as static bodies of information seems to be one of the most important contributions that psychology can make to education.

I have of late been making some laboratory studies of arithmetic. Most people think of number as a kind of abstract idea which is lodged in the mind and is sometimes used in working out a few problems in addition and subtraction. In fact, it is characteristic of the present period of educational evolution to speak slightingly of arithmetic and to advocate its liberal reduction. Mr. Wilson has led many teachers in this country to believe that arithmetic is almost a dispensable part of the elementary program. He has been very caustic in his remarks about arithmetic as a "system."

The experiments which I have been making convince me that number is a very elaborate and very dynamic system. It is a mode of intellectual procedure which permeates all civilized life and is the basis of some of the most important virtues of our present-day civilization.

It is not possible here to review all of the facts on which the foregoing statements about number rest. Two typical facts can, however, be cited in order to give color in your thinking to my assertions. First, counting can be shown to be a very active process. Let anyone note carefully what goes on in his experience when he counts and he will notice that he makes a definite reaction to each unit as he enumerates the objects which he is counting. The laboratory experiments show clearly that the rate at which one counts and the degree of accuracy which one attains in counting depend directly on one's ability to respond actively to the objects presented to one's senses.

The second fact is historical. Number has been evolved as a result of long racial experimentation in the methods of dealing with precision with a complex world. Without number our modern life would be without mechanical contrivances of the kind which are now common but could not have been constructed without the use of instruments of precision and number.

Number is one of the intellectual devices which, like the alphabet

and like our scientific terminology, are the indispensable instruments of modern thinking. To reduce instruction in number to the point suggested by many modern school reformers would be to throw away very lightly one of the most important intellectual inventions of the race.

Try to imagine yourself without number. Suppose you were starting on a journey and could not estimate with precision the distance you were going, the length of time you would be gone, or the cost of the expedition. Life would be a very different matter in its purely descriptive aspects if we could not count.

I have perhaps gone far enough to make clear what I meant when I said that number is a mode of thinking, a method of arranging the world in order so that it can be dealt with in a precise way.

If number and language and geography and history are thought of not as collections of facts but as vital methods of thinking, we get a view of school work which I believe is very illuminating. We realize that the duty of the school is to make of pupils members of an intellectual society which has adopted highly advantageous methods of dealing with the world. We shall not ask how many items of knowledge a pupil possesses, we shall ask rather how far the pupil has learned to use the methods of advanced civilized thought. We shall think of people as equipped for life not merely because of certain inherited traits, but because of methods of intellectual procedure.

I can give some very striking examples of what I mean by referring to a recent book by Truman Lee Kelley, entitled: *The Influence of Nurture upon Native Differences.* Professor Kelley takes the position that maturity is correlated one hundred per cent with chronological age. That is, a child is mature in the degree in which he has lived thru a certain period of time. Again in the latter part of the same book Professor Kelley describes a situation in which a pupil with a high intelligence quotient was in a class taught by a teacher of lower intelligence quotient. Professor Kelley is quite sure that this is criminal maltreatment of the pupil. The child should have a teacher with an intelligence quotient equal or superior to his own.

In absolute contradiction to both of Professor Kelley's contentions is the thesis which I have been defending. A teacher with a relatively low intelligence quotient who is in possession of the most refined racial methods of thinking may teach something of high value to the brightest pupil. The mediocre teacher who knows the Arabic numerals can benefit greatly the child of the highest intelligence quotient who has not yet become acquainted with these very useful instruments of thought. The teacher of moderate intelligence who has studied geography has something to give the inexperienced pupil.

In like terms, it seems to me we must dissent from Professor Kelley's definition of maturity. Intellectual maturity depends not on the length of time one has lived but rather on the methods of thought and action which one has acquired. The child of civilization reaches a level of intellectual maturity which no adult of the savage stage ever reaches. Intellectual life is not merely a matter of the number of experiences, it is a matter of the organization of experience.

What I have been saying can be summarized in the statement that teachers and school administrators should study the progress of pupils in terms of their modes of thinking rather than in terms of the subjects taught. Indeed, subjects taught in the schools merely furnish opportunities for the exercise of modes of thinking. If the modes of thinking go wrong because of neglect on the part of teachers or because the conditions of instruction are such as to cover up inappropriate methods, pupils may be seriously and permanently injured. It is not the subject-matter which educates. It is the method of thinking which constitutes the true center of the educational process.

A Brief Summary of the Essential Facts Concerning the Purpose, History, and Work of the Bureau of Cooperative Research at Indiana University

H. L. SMITH, Dean of the School of Education and Director of the Bureau of Coöperative Research, Indiana University

The Bureau of Coöperative Research, Indiana University, was established in 1914. It was established in connection with the development of the Educational Measurements Conference of Indiana University. These two organizations have developed hand in hand over the period of the last thirteen years. Many of the studies worked out by the bureau have been presented at the Educational Measurements Conferences and later published as a part of their proceedings. Other studies of the bureau have appeared as special bulletins issued by the bureau from time to time.

The Bureau of Coöperative Research at Indiana University was the second bureau of the kind to be established in the United States as far as information available would indicate. It is interesting to note that the first pressure for the establishment of such a bureau came from the field. Superintendents, principals, and teachers felt the need of information that they did not have. A feeling of limitation both on the side of finances and on the side of scholars to do the work forced them to give up temporarily the idea of doing this kind of work themselves, and they urged the universities to undertake it. S. E. Courtiss, who was at that time a teacher in a private school at Detroit, was one of those who felt the need for such a bureau. He made the suggestion to two universities, Indiana University first, and Oklahoma University second, that such a coöperative bureau be established. Indiana University immediately thought favorably of the suggestion but did not see its way clear to finance the proposition until a little later. In the meantime Oklahoma University established such a bureau. A little later on other universities established similar bureaus, and many city school systems and state departments of public instruction have now established such bureaus.

The original purposes of the Bureau of Coöperative Research at Indiana University were threefold and were stated as follows:

(1) To render assistance to school corporations and school officers in increasing the efficiency of school work in Indiana.

(2) To further the growth of educational science.

(3) To stimulate individuals to the further pursuit of educational research.

You will note that the purposes involve research on the one hand and service on the other hand. Both of these ideas have obtained thruout

the history of the bureau, as will be evident from the nature of the work undertaken. Aside from the publication of the proceedings of the Educational Measurements Conferences, which contain many of the studies developed by the bureau, twenty-one special studies have been made and published in pamphlet form and seven others are now in the process of completion.

In the early days the bulk of the work of the bureau consisted in the giving of educational tests in the school systems thruout the state. Arrangements for the giving of these tests were usually made thru some research club in the state, composed of the superintendents of a group of neighboring cities. The test material was furnished by the schools, after being selected by the bureau. The tests themselves were given by the superintendents; the tabulation, interpretation, and publication of results was made by the bureau. "A Coöperative Study of Reading in Sixteen Cities in Indiana," an early publication by the Bureau of Coöperative Research, illustrates this type of the work.

A second phase of the work of the bureau has been that of developing tests. Among such tests are the Childs' Algebra Test, the Childs' Extension of the Thorndike Drawing Scale, the Vannest Diagnostic History Test, the Clark and King Home Economics Test, and, finally, the Indiana Composite Achievement Test, which you heard about this afternoon.

The third line of work of the bureau has been connected with building plans and programs and is divided into two parts: first, the checking of building plans submitted by school boards and architects, and, second, the study and criticism of proposed school building programs in communities in Indiana.

Closely akin to this line of work has been the work of the bureau in connection with school budgets. Under this head some work has been done in compiling school budgets and in developing outlines of budgetary procedure.

Another line of work closely connected also with the work of building plans and school budgets is related to the financial aspects. This line of work is well illustrated by two studies of the bureau: (1) "The Effect of Population upon Ability to Support Education," and (2) "When to Issue School Bonds." Other work of the bureau is related to the devising of record and report forms for proper child and financial accounting.

An additional line of work that the bureau has entered has been that of studies of curricular and instructional problems. An illustration of the former is a publication entitled "An Investigation of Nursing as a Professional Opportunity for Girls." The instructional phase is represented by a recent publication by Dr. Franzén, entitled "A Comparison of the Results Made on Certain Standardized Tests by Pupils in the Bloomington High School Who Were Taught in Classes of the Same Grade by University Student Teachers and by Regular High School Teachers."

The bureau has specialized in the field of bibliographies. The first of these to be published was a bibliography of educational measurements. That bibliography was revised later and is now undergoing a

INDIANA UNIVERSITY LIBRARY

second revision. A bibliography of school budgets was published by the bureau only a year ago.

Another field of work that the bureau is engaged in is that of guiding research studies of graduate students. Many such studies have been completed and a large number are now in the process of investigation. The present studies of the bureau, now in preparation, extend into many of the fields covered thru past activities of the bureau. They are as follows:

(1) Bibliography on school grounds, houses, and equipment.
(2) Bibliography on school surveys.
(3) Investigation of students' attitude toward examination.
(4) Monetary value of a college education.
(5) Standardization of the Indiana Composite Achievement Test.
(6) A study of the duties of the county and city superintendent, in coöperation with the county superintendents and city superintendents of the state.
(7) Various outlines for county and state superintendents for the developing of school supervision.
(8) Coöperation with the Arsenal Technical High School of Indianapolis in the developing of a research program to be carried out by the Technical High School staff under the direction of the administrative officers of the Technical High School staff and the professors of education in Indiana University.

In the original conception of the bureau it was thought advisable to limit the enrollment of members. Two limitations were made: first, a limitation made by imposing a fee for membership; and, second, a limitation which demanded, for continuance of membership, continued participation in research. In more recent years the fee idea has been dropped and the membership has been made up of those who actually attended the conferences, and to those who attend the conference copies of the proceedings are sent free of charge.

The first director of the bureau was Professor M. E. Haggerty, now dean of the College of Education of the University of Minnesota. The next was Walter S. Monroe, at present director of the Bureau of Research in Illinois University. One or two others were selected for the position later but were offered more attractive positions elsewhere before assuming their duties. In the last few years the nominal title of director of the bureau has been held by the dean of the School of Education pending the appropriation of funds that would make it possible for us to develop at Indiana University a bureau that would meet the needs of our state and that would compare favorably with the bureaus in similar institutions.

I should have more satisfaction in outlining a future program for the bureau than in relating its past achievements. Such a program has been prepared and presented to the President. Until larger legislative appropriations for research purposes are made for Indiana University, however, this program cannot be put into effect, and pending the receipt of additional funds the activities of the bureau will have to continue along the modest outlines of the past.

Studies in Grade Placement

CHARLES H. JUDD, Professor and Head of the Department of Education, University of Chicago

THERE was a period in the history of American schools when the problem of arranging the curriculum of the elementary grades solved itself. That was the period when pupils attended school for so short a time that nothing could be taught except the most rudimentary phases of reading and arithmetic. The Commissioner of Education has estimated than in 1840 the average American citizen received only 208 days of school training. This is far too short a period to raise any problems regarding the curriculum.

The situation which confronts the schools at the present time is altogether different from that which was outlined in the foregoing paragraph. At the present time there are a great many pupils who will attend school as long as it can be shown that it is profitable for them to spend time in an educational institution. Coupled with this extension of the period of training is the fact that there is at hand today a vast body of instructional material which is thought of as productive and as desirable for those who want to reach the higher levels of success in life. In short, the demand for education and the opportunities for securing education have increased to the point where a problem unknown in 1840 has thrust itself on the attention of educators.

The new problem which confronts us is the problem of selection and arrangement. Let us consider some illustrations which will make clear the nature of our new problem. The bankers of this country are anxious to have people trained in the ideas and habits of thrift. They have, very properly, recognized the schools as avenues of access to the people and they are doing all they can to encourage the schools to give training in thrift. There can be no doubt whatsoever that lessons in thrift are suitable materials of general education. The problem which arises is the problem of when and where and with a devotion of how much time shall the school take up the topic of thrift. Probably the first grade is too early for any explicit teaching of the principles of thrift, altho the habits of saving may be cultivated even at this early period. Probably the last year of the high school is too late for the most advantageous introduction of instruction in thrift. The exact place where such instruction can be best inserted is a problem of curriculum organization which did not trouble the schools a generation ago, but which is today a very vital matter.

Again, shall thrift be taught as a separate course or shall it be taught as a part of civics, or as a part of home economics, or as a part of history? Shall it take some of the time of the reading class or be treated as a part of arithmetic? Even admitting that it is a

worthy subject to have a place in the schools, that place must be determined with due regard to manifold other interests.

Let us consider a second illustration of a somewhat more general character. It will hardly be questioned in this day and generation that pupils should be made acquainted with the methods and results of science. We live in a world which is so full of contrivances which depend for their construction and even for their use on the mastery of scientific principles that it is highly desirable that every member of the community be trained to understand physics and chemistry and physiology.

Some thirty years ago, acting on the assumption that every well-educated person should know something about science, the elementary schools of this country began to teach what was known as nature-study. After some years of experimentation it became apparent that pupils in the lower grades cannot be taught science in such a form as the scientists of that day approved for the schools. I remember sitting with a group of superintendents some years ago and hearing them talk of what they called the "fake subjects." I asked what the "fake subjects" were and was informed that they were drawing and nature-study.

The trouble with nature-study was not that there was a dearth of scientific material nor that it is undesirable for pupils to know something about science. The trouble was that the information offered to pupils was not suited to their intellectual maturity and to their interests. The material lacked the virtue of proper grade-placement.

Examples could be multiplied without limit. When and in what form are the schools to teach pupils their duties and obligations as American citizens? This is a matter which we have dealt with very inadequately in the past. When and how fully are we to acquaint pupils with aesthetic values? We are growing up as a nation without any of that general appreciation of music and painting which is common in the older civilizations. When and by what means shall pupils be made intelligent about industrial and commercial opportunities? Shall the school assume the responsibility in any degree for vocational guidance or shall the choice of a vocation be thought of as a post-school matter?

If these general examples seem remote from school programs as they now exist, one could cite strictly internal school problems of grade-placement. When should formal arithmetic begin? When should silent reading be emphasized? When should the study of foreign language begin?

These and other questions which will occur to every experienced school officer suffice to make clear what is meant by the term grade-placement. In seeking a method of answering questions regarding grade-placement we are naturally led to a consideration of the capacity of pupils at various stages of their development. There is a close and evident connection between grade-placement and pupil maturity.

It is to be said at once that pupil maturity is not the only matter to be considered in arranging the school program. For example, there is a great body of English literature which pupils in the ninth grade

or any other grade can understand. We demand of the school the selection of what we call the best examples of literature appropriate for each of the grades. It is entirely proper and it often happens that selections which would have been understood in the ninth grade are postponed for various reasons to the tenth or twelfth grades. One can say negatively that no literary selection should be inserted in the curriculum too early to be comprehended. Such a selection does not necessarily find a place in the program of the school as early as it might. When it becomes suitable it remains suitable for some time and its incorporation in the curriculum will depend on considerations other than pupil maturity.

The foregoing qualification of the statement that grade-placement depends on pupil maturity should be kept constantly in mind in the course of the following discussion. In the face of this qualifying remark, however, it is appropriate to say with emphasis that the most important single factor in determining grade-placement is pupil maturity. If we understand pupil maturity we shall make progress in the solution of curriculum problems more than thru the consideration of any other matter.

Fortunately we have sufficient observations on which to base a series of general statements regarding the major changes which take place in the mental attitudes of pupils in school. We know, for example, that there is in the primary grades a period during which pupils are wholly uncritical. They are satisfied with the drawings which they make as illustrations of narratives even tho these drawings do not represent with any recognizable details the objects which they are supposed to represent. At this age pupils listen without skepticism to fairy stories which are full of the most impossible happenings. Primary pupils are very imitative and in this sense are very teachable. They are so much interested in other people that they are easily led by example.

All of these facts are symptoms of a type and degree of mental maturity which must be recognized in the arrangement of the school curriculum. Indeed, it is only in the light of such facts that one can possibly understand the history of schools. Again and again reformers have attacked the curriculum of the primary grades saying that reading at that stage of life is artificial and too difficult. Handwriting has been described as requiring a kind of muscular coördination which overtaxes little children. Fairy stories have been attacked again and again as misleading and unscientific. In the face of all these attacks the primary program survives and promises to continue to the end of time.

The fact is that the mental characteristics of children of the primary grade period are exactly suited to the instruction in the first stages of reading and writing. It requires the highest degree of social docility to accept the arbitrary associations which must be made between written characters and the sounds which they represent. There is absolutely nothing natural about the letter *a* and its association with the sounds which it represents. No one except a child eager to follow the social lead of his elders would accept the arbitrary dictum that *a* stands

for a certain sound and that the letters *b-o-y* spell the well-known word "boy." The primary school period is a period of uncritical social imitation and as such is exactly the period when the social arts can be most readily taught. The arts of reading and writing are not taught in the first grade because they are most useful at this period in the child's life, but because they are most appropriate to a period of uncritical imitation.

By way of contrast with the arbitrary and imitative character of reading and writing we may refer once more to the failure of nature-study in the early grades. Scientific thinking is critical and for this reason is impossible in the primary grades. Pupils will not interest themselves in the structures of animals at that stage of life because there are no standards of structure in their minds. They accept all animals as they are presented—dragons breathing fire quite as readily as birds with wings or frogs that can both swim and walk. When little children in the first and second grades are allowed to express their personal interests in animals by asking questions, they ask where they can get one and whether it will bite; they do not ask critical scientific questions.

Following the uncritical primary period there comes in the middle grades a wholly different type of attitude and a wholly different stage of maturity. Children in the fourth, fifth, and sixth grades are not imitative as they were in the primary grades. They are self-assertive; they begin to be self-conscious and are often quite combative. Pupils of this age are not unlikely to be difficult to discipline and they are often difficult to lead. Their new attitude is in many respects opposite to that exhibited in the primary grades.

The explanation of the situation is simple enough when one recognizes that social imitation naturally leads to a growth of self-consciousness. The very effort to be like other people gradually exhibits to oneself one's own peculiarities. Primary pupils have been gradually passing thru experiences which inevitably make them aware of their own characteristics. The self-consciousness of the middle grades is a sequel and natural product of the uncritical imitation with which school life began.

What is the proper material with which to meet the new intellectual demands of pupils in the middle grades? I remember reading in one of the older books on school methods the statement that the fourth, fifth, and sixth grades are periods of drill. This statement is, I believe, the expression of an attitude of despair on the part of the formal pedagog who found that intermediate pupils are difficult to manage and consequently decided that the only way to save the face of formal pedagogy was to insist on drill of so rigid a type that escape would be impossible.

The sympathetic student of child psychology has no difficulty in selecting the program for the middle grades. What the pupil needs and wants is information about the world. The wise judgment of teachers has put into this period the study of geography. Nothing could be more appropriate. The independent, often untractable child

wants to wander up and down the world and see its strange sights for himself. Stories of earlier civilizations are appropriate, too, and opportunities to make things so that one may feel oneself master of the physical world.

The middle grades have been the relatively neglected grades in American schools. It is here that one usually finds the least experienced teachers. Primary grades have usually been fortunate in securing highly efficient teachers, and the grades just before the high school have been put under the charge of well-qualified teachers. The middle grades have been turned over to the novice and to the mediocre teacher. The result is that the middle grades have never had the distinctive character of the grades above and below.

There is, I believe, a large opportunity here for the exercise of real educational genius. There will be, I venture to prophesy, much experimenting in the next few years with new types of instructional material in the fourth, fifth, and sixth grades. I look for an enlargement of geography and history and for the liberal introduction of some kind of natural science and some kind of constructive work.

Whether my prophecies are realized or not, one principle I am sure will be recognized, the middle grades cannot be treated as mere continuations of the primary grades. It has been true in the past that methods of teaching which were found to be successful in the lower grades tended to be carried forward without modification into the grades above. We have seen reading, for example, taught by primary methods which emphasized oral reading even as late as the eighth grade. The carrying forward of methods of the lower grade is the result of an undue devotion to subjects and a total neglect of the psychology of pupils. Anyone who makes even a superficial study of the mental characteristics of pupils knows that middle grades cannot be successfully taught by methods or with materials appropriate to the primary grades. Mental development has carried pupils to a new stage, and the curriculum must take on a correspondingly new form.

Following the middle grades there comes another new and very interesting period—the junior high school period.

It is a very striking confirmation of some of the statements made earlier in this paper that the junior high school period long remained undiscovered. In the early days when pupils went to school for so short a time each year that they never really mastered the social arts, the characteristics of mental maturity were so covered up and obscured that no one really understood the special nature and the special needs of junior high school pupils. There was no sharp line drawn and no change in the school program corresponding to the arrival of the pupil at his twelfth or thirteenth birthday. The expansion of school opportunity has brought the junior high school period to clear recognition. Pupils of twelve years of age have in our day mastered reading and writing so thoroly in the imitative period and they have become sufficiently acquainted with the world during the middle grades that with the beginning of adolescence their interests can express themselves with unmistakable vividness. The junior high school period is a new period

of social interest. It is not like the primary period during which social interest was uncritical and purely imitative. The pupil is conscious now of himself and he approaches society in a new mood; it is the mood of a candidate seeking admission. The junior high school pupil is old enough now to think of himself as a prospective participant in the world's work. He is eager to know how society organizes its industry and how it distributes its rewards. He is interested in people. Boys of this age are interested in girls and girls reciprocate. The middle grades are unsocial grades. The junior high school is a period of keen social interest.

The recognition of the junior high school period as a time requiring a curriculum of its own was by no means the first step in the movement to organize this new type of school. In fact, there are a great many junior high schools even today which are unprovided with a distinctive program of studies. The junior high school had its origin in the recognition of a series of distinctions which had to do with school discipline and methods of teaching. Pupils in the seventh and eighth grades were found to be too mature to play with pupils in the lower grades. Departmentalization of the upper grades came as a concession to the superior maturity of upper grade pupils long before there was a special curriculum for the seventh and eighth grades. On the side of the high school, the ninth grade set itself off from the higher grades. The pupils in the ninth grades did not seem to belong to the high school group. They played apart and thought differently.

Recognizing vaguely the distinctions in maturity which have been described, school administrators separated junior high school pupils from pupils in the lower grades. They did this in many cases before they had any clear ideas as to what should constitute the curriculum of that school. Indeed, the first motive of separation in many localities was the desire to relieve building congestions. The result is that we have in the United States at the present time every possible shade and variety of junior high school. We have combinations of grades including at one extreme the sixth grade and at the other the tenth. We have junior high schools housed with elementary schools, junior high schools housed with high schools, junior high schools housed alone, and junior high schools in process of transfer from one status to some other. We have junior high schools with programs of studies so like those which were in operation before the new organization was attempted that no one can distinguish them from the earlier programs. We have junior high schools which have attempted to put the full high school program down one or two years into the grades. In short, the junior high school is at the present time the home of chaos.

I believe that it is possible to clear up much of the fog which at present surrounds the junior high school by frankly organizing its operations on the basis of the known facts regarding the mental characteristics of pupils of twelve to fifteen years of age. These young people have mastered the social arts, they have some information, and they are looking forward to careers in the business or commercial or professional or domestic world. It is this forward look which dictates the

subjects which should be taught. The junior high school should base its whole curriculum on the social sciences. The stories which have been taken from history and have become somewhat familiar in the lower grades should be gathered up and focused on the present so that pupils may be led to understand that present-day institutions are the results of human efforts to live together. The facts about industry and commerce which have been located and described in geography should be discussed from the point of view of their human significance. The methods of precise thinking which have been cultivated in arithmetic and the devices of communication which reading and writing have given the pupil should be re-evaluated for the pupil in terms of their significance as instruments of social coöperation.

I believe that the junior high school is the strategic point in the school system for a reconstruction of the curriculum if only the fundamental principle can gain recognition that the curriculum is not an external matter dictated by some accidental cause and brought into the school to be imposed arbitrarily on the pupils. The curriculum should be in fact a series of opportunities for the pupils to mature in accordance with their naturally growing powers. The world must be mastered by each individual in such a way and to such a degree as comports with his maturing powers. The junior high school is an institution which has been evolved to provide appropriate experiences for pupils from twelve to fifteen years of age. The only way in which this new type of school can do its work properly is to make an intensive study of the maturity of pupils and to select its materials of instruction in the light of its findings.

Beyond the junior high school the problems of grade-placement take on a new character because the needs of individuals differ so radically that it cannot be said that there is any longer a general problem of grade-placement. During recent years the elective system has been recognized in American high schools as a necessary device to meet the differences in the needs of individual pupils.

No one who has observed the elective system in operation can deny for a moment that it has suffered from the grossest abuses. School officers have not known what sequences of studies best suited the requirements of individual pupils. Parents have been equally at sea in this matter. Both teachers and parents have been influenced by tradition to a degree that is pathetic to contemplate. High school education is at the present time hardly more than a collection of hopeful accidents. In certain respects high school education at the present time is in the condition in which elementary education found itself two generations ago. There is so much material at hand which seems to be worth teaching that there is clearly no possibility of carrying any individual thru the whole body of this worthy material. The school accordingly proceeds without much discrimination to use as much of the available material as possible, depending on the unsystematic judgment of teachers to make the adjustments demanded by the maturity of pupils.

I am not sure as to the way in which the high school situation is to be cleared up. It seems fairly evident that studies are needed to

determine more fully than is now known what are the general elements of the higher forms of knowledge and also what are the essential elements of knowledge required in various lines of specialization.

I can illustrate what I mean. One of the high school subjects which is under heavy fire at the present time is mathematics. Nobody seems to be sure whether algebra and geometry contribute essential or non-essential elements to the mental development of high school pupils. There are many minds as to what should be done under these circumstances. One group of thinkers contends that the safe procedure in view of existing uncertainty is to go on teaching mathematics on the theory that there must have been some real reason for the original introduction of mathematics into the school program. The opposing party of thinkers holds that safety dictates an abandonment of mathematics until the case in favor of this subject is more adequately proved.

One might turn to another subject for illustration. English has within a generation reached a preferred position in the high school program which hardly seems defensible in view of the results which issue from English teaching. There are very few who have the boldness to suggest any large reduction in the number of courses in English, but there are a great many who feel quite certain in their private thinking that English courses are very slender in their content and highly formal in their methods.

I repeat that I do not know how to suggest remedies for the uncertainties and inadequacies of the high school curriculum. There is one statement that I shall venture to make. It is that the high school people need to be shaken out of their too general complacency with the present situation.

The same statement can, I think, be made with regard to the curriculum of the college. In both of these higher institutions there is some restlessness, and I believe there will be more in the future, because of lack of clear-cut scientific principles governing the formulation of curriculums.

Perhaps there is justification for an evasion in this paper of the difficulties which appear in the high school and college. Perhaps the principle of grade-placement needs to recede at the upper levels of education in favor of some other principle of curriculum construction. I do not believe that such an admission weakens in the least the contentions which were urged in the early paragraphs of this paper. In the elementary school and in the junior high school the choice of material of teaching is governed very largely by the ability of pupils to take on the practices of civilization. Progress thru these lower grades is marked by certain radical changes in mental attitude which call for corresponding changes in methods of teaching, for sharply differentiated forms of administration, and for appropriate placement of materials of instruction. If school people can be made aware of the necessity of studying grade-placement in the grades, the way will be open for a later and perhaps different line of attack on the program of the higher schools.

An Experiment in the Content of High School Physics

CARL G. F. FRANZÉN, Professor of Secondary Education in Indiana University

DURING the year 1926-27 a seminar course in the secondary school curriculum was organized in the School of Education in order to make intensive studies of various and special phases of the content of the secondary school subjects. The group which formed the seminar this year decided to investigate the extent to which physics, as taught in the high schools of the state, means more than just the type of information gained from the textbook. It was somewhat of a problem at first to decide just what particular attack to make upon the subject. The various textbooks that are now used in physics were examined as to the type of content which each contained. In spite of the names which the various textbooks might carry it was found that the chief emphasis was placed upon the laboratory-manual type of information. The question then arose: To what extent do pupils derive much of a connection, if any, between these principles and phenomena and the various situations in ordinary life which exemplify these same principles or phenomena?

With this purpose in view it was decided to formulate some kind of test which might give an indication as to the extent to which there is any transfer from the physics taught to physical occurrences in everyday life. In the construction of this test several attempts had to be made to find just the type to use before the final selection was made. True-false, multiple choice, and the matching types were considered. The last type was selected because it seemed to suit much better the analysis of what we were after, for, aside from the purpose that has been already mentioned, namely, that of finding out to what extent pupils see connections between principles and occurrences, we wanted to know to what extent the study of other sciences might or might not contribute to the pupil's ability to do well on this test. Another consideration was the extent to which college and university students show any carry-over from their high-school physics.

In selecting the ground to be covered the choice was limited to the fields of Mechanics, Heat, and Sound, because these three phases are usually the only ones that are covered in the first semester of physics. Twenty applications were made in the field of Mechanics and ten each in Heat and Sound. In order to guard against the weakness of perfect matching, certain principles were included in the list which were not used to illustrate certain applications, while other principles were used twice in answers to applications. In so doing we felt that no pupil could figure out very well by the process of elimination what principles might apply: if he did not know, then many of his answers would have to be the result of guess-work. When the test and instructions were organized in their final form they were submitted to some of the instructors in the mathematics and the science departments for criticism as to the correctness of statements and the principles used to explain those statements. You have in your hands the test which was used.

Name.....

Physics Principles of Mechanics, Heat, and Sound

A. Instructions to the pupil:

On this page will be found a list of principles which you have studied in physics. On the other pages will be found a list of common applications or illustrations of these principles. You are to read each application or illustration and then decide which one of the principles on this page is most nearly related to it. On the blank line to the left of the illustration on the other pages write in the number of the principle that governs it. If you find that more than one principle applies to any application or illustration, or if you have difficulty in finding a principle that applies directly according to your way of thinking, write down the number of the principle that applies best. For example: We write an *8* in the blank space in front of the first illustration because the principle of surface tension is the one that governs it.

N.B. It is well for you to know that some of the principles are used more than once and some are not used at all.

B. List of physics principles:

Mechanics

1. Pascal's Law
2. Archimedes' Principle
3. Boyle's Law
4. Atmospheric pressure
5. Viscosity or cohesion
6. Adhesion
7. Hook's Law
8. Surface tension
9. Capillary attraction
10. Molecular motion in gases
11. Resolution of forces
12. Momentum
13. Centrifugal force
14. Mechanical advantage
15. Friction
16. Charles' Law
17. Inertia
18. Reaction
19. Mechanical efficiency
20. Center of gravity
21. Tenacity

Heat

22. Expansion
23. Non-conductivity
24. Radiation
25. Convection
26. Humidity
27. Evaporation
28. Specific heat
29. Boiling point
30. Distillation
31. Mechanical equivalent of heat
32. Latent heat

Sound

33. Vibration
34. Doppler's Effect
35. Pitch
36. Sympathetic vibrations
37. Reflection
38. Rate of transmission
39. Overtones
40. Resonance

	8	1. It is possible to make bubbles out of soapy water.
M	9	2. Wicks for coal-oil stoves.
S	37	3. It is less difficult for a public speaker to make himself heard indoors than outdoors.
H	23	4. Hot dishes are often set on table mats.
S	40	5. When the nose is stopped up by a cold in the head the voice sounds different from the way it usually sounds.
M	5–21	6. Taffy may be pulled quite a distance before it comes apart.
S	36	7. A piano often is heard producing a tone after a person has finished talking in the same room altho the keys were not touched.
M	1	8. A jug full of water is often broken when the stopper is tapped in tight.
M	20	9. It is impossible to stand sidewise against a wall on one foot, when that foot touches the wall.

M	9	10. Blotters.
S	34	11. If the horn of an automobile is sounded as it approaches you it seems to produce a sharper sound than if the automobile were standing still.
H	22–25	12. Hot air furnace.
M	4	13. A person may use straws in drinking liquids.
H	30	14. A lid over a kettle of boiling water will be found to have drops of water on its under surface.
S	33	15. The wings of a flying bumble bee produce a distinct audible sound.
M	10	16. The odor of perfume may be sensed at a considerable distance even when no breeze is blowing.
M	7	17. Spring scales.
M	6	18. Chalk clings to a blackboard.
S	35	19. If a phonograph runs down while a record of a tenor solo is being played, it becomes a baritone solo.
M	2	20. Most of our present-day ships are made of steel, a material much heavier than water.
S	39	21. Music of stringed instruments is considered by most people to be of higher quality than that of other musical instruments.
M	12–17	22. A person is apt to fall in alighting from a rapidly moving vehicle.
M	4	23. In order to make condensed milk run evenly and more quickly a second hole is punched in the top of the can.
M	12	24. The higher the point from which an object is dropped the harder it strikes the ground.
H	24	25. The outer surface of the glass portion of a thermos bottle is silvered.
S	40	26. A pipe organ is capable of producing a great volume.
H	27	27. A drop of alcohol placed upon the hand causes a colder sensation than a drop of water at the same temperature.
S	37–40	28. A person can hear better when his hand is cupped behind his ear.
H	23	29. Wooden handles instead of metal handles are usually found on tea kettles.
M	15	30. A man may bring his Ford to a stop by means of brakes.
M	13	31. In a cream separator the heavier milk is separated from the cream.
H	26	32. On certain days water moisture collects on our drinking glasses.
M	3	33. Many water coolers consist of a large inverted glass bottle. When the faucet is turned on bubbles of air go up thru the water. The bubbles increase in size as they move upward.
M	8	34. Water spiders walk on the surface of the water.
M	14	35. A man raises the wheel of his car by means of a jack.
M	11	36. A sail boat can travel at right angles to the wind.
H	32	37. Ice is more effective than ice water in cooling a refrigerator.
M	2	38. A rock lifted from the bottom of a stream seems to weigh less while under the water than after it is out of the water.
H	28	39. Hot water bottles make better foot warmers than flat irons.
S	38	40. Soldiers at the rear of a procession, headed by a band, march out of step with those at the front.
H	22	41. The joints between the rails of a railroad track are wider in winter than in summer.

The next step to consider was to find out what schools would be willing to coöperate in assisting us to find any results that might come from the use of the test. Instead of sending out a wholesale request for such coöperation we took the State School Directory and went thru it to find which schools that taught physics had principals or science teachers who were known to members of the seminar group. Each person then made himself responsible for writing to these friends and asking if they were willing to give the test. When the answers to these letters came back we sent as many copies of the test as there were members of the physics classes in each school with a return envelope, postage first class. The schools were divided rather arbitrarily into two classes, the small and the large schools. The coöperating small schools were Valley Mills, Walton, Gaston, Vallonia, Wawaka, Tyner, Batesville. The coöperating large schools were Bedford, Huntington, Tipton, Kokomo, Bloomington, Lafayette, and Shortridge. Tests were given somewhere around the first week in March. The results have been tabulated in order to find some indication of the extent to which this particular test may or may not serve the purpose for which it was prepared.

Teacher's Instruction Sheet and Report
to accompany

THE TEST IN THE APPLIED PHYSICS OF MECHANICS, HEAT, AND SOUND

To the Teacher

Your coöperation is being enlisted in an effort to find out to what extent high-school pupils who have had a semester or more of physics are capable of seeing any relationship between the applications of physics as practiced in ordinary life and the theories studied in their textbooks. To that end we have asked you to administer the accompanying tests to your second-semester physics class or classes. You will note that page 2, which contains Instructions to the pupil and the list of Physics Principles, is separate from the test. When you are ready to give the test, distribute one copy of the test and page 2 to each pupil in the class.

DO NOT GIVE THIS TEST LATER THAN MARCH 1, 1927

When the tests have been distributed, tell the pupils to do NOTHING until told to do so by you. Have them fill out all the information asked for on the Cover Page. When they come to the question that asks for the occupation of father or guardian tell them to write the occupation with which they are most familiar. The chances are that this is the occupation of the father, or whoever it is that the pupil has spent most of his life with. Tell the pupils to write in numbers 0, ½, 1, etc., in the spaces that call for the amount of time they have studied other sciences in school.

The pupils should be allowed *at least* thirty minutes in which to do the test after they have finished page 1 and have been told by you to turn to page 3.

DO NOT GIVE THIS TEST LATER THAN MARCH 1, 1927

In order that we may know how much ground you have covered in your class, so that we may know what topics in the test your pupils are not expected to answer, will you please answer the following questions and return this sheet with your test to Dr. Carl G. F. Franzén, School of Education, Science 36, Indiana University, Bloomington, Ind. Postage and a return envelope are being sent you where the number of tests is small; otherwise, send the tests by C.O.D. express to the above address.

Name of teacher.....

Name of school.....

Date school began in fall..... Date test was given.....

Name of text used..... What edition?.....

Underline the divisions of physics which your class has studied: mechanics, heat, electricity and magnetism, sound, light.

Remarks:

High School Students

A Test in the Applied Physics of Mechanics, Heat, and Sound

Cover Page

Fill in blanks below

Name of pupil..... Date.....

Date of birth..... Boy or girl.....

Name of school.....

Class or grade in school.....

Occupation of father or guardian.....

What occupation do you expect to enter?.....

If you have had any of the sciences listed below, write after each one the number of years or half-years you studied each.

General Science	
Physical Geography	
Botany	
Biology	
Physiology	
Zoölogy	
Chemistry	
Physics	

Have you failed in any of the above subjects?.....

If so, what ones?.....

DO NOT TURN PAGE UNTIL TOLD TO DO SO BY THE TEACHER

University Students

A TEST IN THE APPLIED PHYSICS OF MECHANICS, HEAT, AND SOUND

Name..... Date....., 1927

Date of birth..... Sex: Male....; Female....

Special course (if any) you are pursuing in the university (such as teacher training, medical, law, journalism, etc.).....

Your major subject or subjects.....

Your minor subject or subjects.....

Your class in the university. Indicate by a check mark. Freshman...; Sophomore....; Junior....; Senior....; Postgraduate....; Special Student....

Indicate by a check mark the type of community in which you spent the major part of your childhood: rural....; village....; non-industrial town or city....; industrial town or city....; mining town or city....

Occupation of your father (or of your step-father, foster-father, mother, or any other person who provided the financial support for the family in which you spent the major part of your childhood).....

.....

What occupation do you expect to enter?.....

Sciences you have studied or taught. In the first column below place a check mark after each science you studied in high school; in the second column place a check mark after each science you have studied in college; in the third column place a check mark after each science you have taught in high school or elsewhere.

	Studied in High School	Studied in College	Taught
Physics	....	....	....
Chemistry	....	....	....
General science	....	....	....
Biology	....	....	....
Botany	....	....	....
Zoölogy	....	....	....
Physiology	....	....	....
Physical geography	....	....	....
Geology	....	....	....
Astronomy	....	....	....
Psychology	....	....	....
Others:			
.....	....	....	....
.....	....	....	....

DO NOT TURN PAGE UNTIL TOLD TO DO SO!

You will notice that the first page asks for certain information in regard to the pupils taking the test. The idea involved was that possibly there might be some connection between the various kinds of information requested and the type of responses made by the individual. We thought that this might particularly be true in regard to the number and amount of other sciences that had been studied.

As is almost always the case in an investigation of this kind, the tabulation of results brings out several things of interest which had not been anticipated by the makers of the test. These items will be pointed out as we come to them.

In the analysis presented to you today we shall consider the types of answers given for various items on the test; the most characteristic errors; the frequencies of correct, wrong, omitted, and multiple responses on each item; the number of principles in each of the three fields which have been used to explain the item; the scores made by boys versus girls in the small and large schools according to the other sciences which have been studied; the extent to which there is any difference to be noted whether or not pupils have studied sound before taking the test. In only one instance, that of Wawaka, the subject *heat* had not been studied, but since there were so few pupils in this school an exception was not made in this case.

We shall also consider rather briefly the results made by college students. It may be necessary to state that in order to avoid duplication, students taking the test were selected only from the classes in secondary education under Dr. Foster, Mr. Marshall, and myself. The total number, 86, was not very large, but it does give some information which may be compared with the results of the high school pupils.

If you now turn to the test on pages 43 and 44 you will find the instructions to the pupil and the physics principles listed according to the description that has already been made. This page with the list of principles (page 43) was not assembled with pages 3 and 4 (of the test) in order that the pupil might more conveniently refer to it in getting his answers to the test items.

TABLE 1—GENERAL DATA

1	2	3	4	5	6	7	8	9	10	Number of Principles in Each Field to Explain				Total Number Incorrect Principles
			M	H	S	C	W	O	M	11 Rank	12 M	13 H	14 S	15 All
2	M	9	6	25		204	74	24	2	13	12	8		20
3	S	37	4		40	109	152	41	10	30.5	4	4	7	15
4	H	23	6	24		209	85	8	5	8	6	8	2	16
5	S	40			35	58	175	69	7	38	4	3	7	14
6	M	5-21	6	22		204	91	7	7	13	7	3	1	11
7	S	36			33	145	123	34	7	24	3		7	10
8	M	1	4	22		116	179	7	6	29	11	1	1	13
9	M	20	12			218	55	29	5	4	13			13
10	M	9	6	27		172	110	20	1	18.5	10	5		15
11	S	34	12		38	83	162	57	5	32	3		7	10
12	H	22-25		24		139	153	10	6	25	4	8		12
13	M	4	9			121	152	29	3	28	16	2	1	19
14	H	30	4	27		109	187	6	6	30.5	7	8		15
15	S	33			36	172	79	51	1	18.5	5	1	7	13
16	M	10	4	27		169	103	30	4	20	10	7	3	20
17	M	7	21			129	147	26	1	27	16	1	1	18
18	M	6	5			205	88	9	1	10	9	1		10
19	S	35			38	66	179	57	4	36	3		7	10
20	M	2	3			215	69	18	5	5	11	2	1	14
21	S	39			36	39	201	62	11	40	4		7	11
22	M	12-17	13			224	75	3	9	3	13		2	15
23	M	4	3			210	63	29	1	7	17	4		21
24	M	12	20			168	124	10	5	21	16	1		17
25	H	24		23		81	207	14	7	33	8	10	1	19
26	S	40			33	76	161	65	13	35	5	1	7	13
27	H	27	18	28		196	91	15	4	16	4	10	1	15
28	S	37-40			34	185	54	63	2	17	1	1	7	9
29	H	23		25		256	45	1		2	2	6	1	9
30	M	15	14			211	88	3	5	6	12			12
31	M	13	2	30		167	102	33	2	22	17	1		18
32	H	26	4	27		205	81	16	3	10	8	8	1	17
33	M	3	4	22		52	209	41	5	39	16	7		23
34	M	8	2			205	77	20	3	10	11			11
35	M	14	19			199	89	14	5	15	13			13
36	M	11	18			138	100	64	4	26	18	2	1	21
37	H	32		27		61	205	36	7	37	9	10	1	20
38	M	2	3			204	80	18	4	13	15	2		17
39	H	28		24		78	207	17	12	34	2	10	1	13
40	S	38			34	164	77	61	8	23	7	3	7	17
41	H	22	16			272	26	4	3	1	7	5		12
						6,234	4,725	1,121	200					

We are now ready to consider Table I, which contains the general data upon which most of our discussion will be based. Column 1 lists in order the number of the items of the test. Column 2 indicates the field in which each of these items falls,—Mechanics, Heat, or Sound. Column 3 gives the number of the principle which is the correct explanation of each item on the test. Columns 4, 5, and 6 indicate the number of the principle and the field in which it occurs, which is used the most frequently aside from the right one to explain the application. Columns 7, 8, 9, and 10 state the number of times each item has been answered, *c*, correct; *w*, wrong, that is, some principle, other than the right one, has been used to explain it; *o*, omitted, that is, no attempt was made to show what principle applied; and *m*, multiple response, that is, the number of times that pupils listed more than one principle in explanation of the item. Since the directions specifically call for the statement of one, and only one, principle, we called all multiple responses

incorrect even tho one of them may have been the correct answer. Column 11 indicates the rank of each item from 1 to 40 according to the frequency of correct response. Columns 12, 13, and 14 show the number of principles in each field that have been used by all pupils to explain the test item. These three columns differ from those of 4, 5, and 6 in that the latter give the modes of the incorrect answers. Column 15 gives the total number of incorrect principles used in explanation.

No further explanation is necessary for column 2. It will be observed that in column 3 there are four cases, namely 6, 12, 22, and 28, in which we finally agree to permit two responses as being correct. What is particularly interesting in the next three columns, 4, 5, and 6, is the extent to which high-school boys and girls who are studying physics fail to give the correct explanation and choose some other explanation. Several of the items will be quoted to show some of the peculiar responses made. In item 2 the most frequent incorrect explanation is that wicks for coal-oil stoves are explained by adhesion. Number 6, "Taffy may be pulled quite a distance before it comes apart," is also explained as due to adhesion. Item 8, "A jug full of water is often broken when the stopper is tapped in tight" because of atmospheric pressure, has the pressure element all right but where is the atmosphere? Item 9, "It is impossible to stand sidewise against a wall on one foot when that foot touches the wall" is for some peculiar reason attributed to momentum. Adhesion again is thought to explain blotters, item 10. That a person may use straws in drinking liquids, item 13, is due to capillary attraction gets in the attraction but where is the capillary? And when, item 15, "the wings of a flying bumblebee produce a distinctly audible sound," is explained by sympathetic vibrations, one wonders who gets the sympathy if these vibrations get too near. Of the forty items, all except two have the mode occurring within the proper field, but items 16 and 41 fall outside their proper domains. Evaporation as a heat principle is used to explain the sensing of the odor of perfume, whereas Charles' Law, a Mechanics principle, explains the heat idea of expansion in item 41. When the rate of transmission is used to explain item 19, it is possible to see that the pupil was thinking of something, but this something was not quite on the subject. The proportion of errors was almost as great on this item for those that had studied Sound as for those who had not studied it. It is perfectly evident that principles 1, 2, 3, and 16 are used when the individual is at a loss as to the exact meaning of these laws. You find evidence of this in item 20, which is explained by Boyle's Law. It is also the case with items 23 and 38. Archimedes' principle, No. 2, on the list, supposedly gives the explanation for item 31, "In a cream-separator the heavier milk is separated from the lighter," and item 34, "Water spiders walk on the water." The same situation is true of principle 34, Doppler's Effect in Sound. It is used to explain item 28, "A person can hear better when his hand is cupped behind his ear," and item 40, "Soldiers at the rear of a procession, headed by a band, march out of step with those at the front." Other illustrations might be given but

you may discover these for yourselves, by working out the rest of columns 4, 5, and 6.

The chief item of interest in the next four columns, 7, 8, 9, and 10, is, of course, the frequency of correct response for each item, and the rank of each as given in column 11. We discover that items 41, 29, 22, 9, and 20 occupy the first five positions relatively with respect to the ease with which they have been answered correctly, and that items 21, 33, 5, 37, and 19 represent respectively the five which have been answered correctly the least often. In other words, they were the most difficult ones for the pupils to explain.

Another point to consider in Table I is the variety of answers given to the different items. Columns 11, 12, 13, and 14 indicate how many different principles were used to explain each item in each of the three fields. For example, for item 2, 12 under M means that 12 of the 21 different Mechanics principles were used to explain why wicks are used for coal-oil stoves, and that 8 out of the 11 heat principles were used for the same purpose. The only relation that might be seen between heat and item 2 is that coal-oil stoves sometimes give heat. By glancing down columns 12, 13, and 14 it will be observed that items 9, 30, 34, and 35 are the only ones whose explanations are limited to the field in which these items are placed, and in every instance this happens to be in Mechanics. On the other hand, items 2, 10, 18, 23, 24, 33, and 38 are items within the field of Mechanics that are also explained by heat by many of the pupils. The items receiving the worst treatments in this respect are numbers 2 and 33, wicks and water-coolers. The only possible reason that no Sound explanation was given for principle 33 was undoubtedly due to the fact that the element of Sound did not enter in. But why there should be almost half as many Heat as Mechanics principles used in this explanation can be explained at present only by the element of guess work. Items 12 and 41 are in the field of Heat with additional explanations in Mechanics. Item 13, "A person may use straws in drinking liquids," is by one individual explained as being due to Doppler's Effect, principle 34. Item 41, it will be remembered, was the easiest one to answer, and yet, when the errors were made, the largest number occured not only in the field of Mechanics but in the number of Mechanics principles used, of which the most peculiar one was Charles' Law, number 16. Items 6, 8, 13, 16, 17, 20, and 36 are in the field of Mechanics but are also explained by Heat and Sound principles. For example: "expansion under heat" is used to explain that taffy may be pulled quite a distance before it comes apart, item 6. And in item 8 it is vibration that causes the jug full of water to be broken when the stopper is tapped in tight, and so on down the list.

Let us consider some of the erroneous answers in Sound. Principles 11, 19, and 21 are the only ones which are explained by Mechanics principles as well as Sound. The other 7, namely, items 3, 5, 15, 26, 28, and 40 find their explanations in all three fields. Let us look at just one or two of these. Number 28, "A person can hear better when his hand is cupped behind his ear," was explained by two people as being due to atmospheric pressure. Item number 40, which is concerned with Sound,

has such wonderful explanations as principle 19, "Mechanics efficiency," principle 4, "Atmospheric pressure," and principle 24, "radiation." Evidently we have some pure guess work here again.

TABLE II—MEDIAN SCORES MADE BY PUPILS WHO HAVE STUDIED SCIENCES OTHER THAN PHYSICS

			Small Schools			Large Schools			All Schools		
			Boys	Girls	All	Boys	Girls	All	Boys	Girls	All
I.	General Science	f	8	6	14	51	12	63	59	18	77
		Md	21	13	19	23	14	22	23	13	21
II.	Physical Geography	f	11	3	14	31	11	42	42	14	56
		Md	22	14	21.5	21	22	21.5	22	19	21.5
III.	Botany	f	13	13	26	28	9	37	41	22	63
		Md	19	14	17	25.5	21	25	24	17	22
IV.	Biology	f	5	1	6	22	2	24	27	3	30
		Md	22	20	22	22.5	14	20.5	22	18	22
V.	Physiology	f	8	7	15	39	5	44	47	12	59
		Md	21	13	17	21	16	21	21	13	20
VI.	Zoölogy	f				10	2	12	10	2	12
		Md				25	19.5	25	25	19.5	25
VII.	Chemistry	f	4		4	29	7	36	33	7	40
		Md	30		30	23	23	23	24	22	22.5
VIII.	No Science	f	16	15	31	42	27	69	58	42	100
		Md	24	11	21	24	19	22	24	17	21
IX.	One or More	f	30	20	50	113	39	152	143	59	202
		Md	22.5	13.5	18	23	19	22	23	17	21.5
X.	All Pupils	f	46	35	81	155	66	221	201	101	302
		Md	22	13	17	23	19	22	23	17	21

Table II, as is noted in the statement, gives the median scores made by pupils who have studied sciences other than physics. The data in this table have been tabulated for small and large schools separately for both boys and girls according to the number who have previously studied any other science in high school. The last three rows in the table show how many have not studied any other science and how many have studied one or more sciences, so that the last row is a summation of the two above it. We find that there was a total of 81 pupils in the small schools, 221 in the large schools, making a total of 302 apportioned among boys and girls to the ratio of about 2 to 1, altho relatively more girls are taking physics in small schools than they are in large schools. The science studied by the least number of pupils was zoölogy; the most frequent subject was general science; while the ratio of those who had studied one or more sciences to those who had previously studied no science was about 2 to 1, being greater for the large schools than for the small schools.

It is rather needless to go thru all the items of this table as it would make this part of the presentation entirely too tedious. You may for yourself make any comparisons that you care to, with the understanding that "f" stands for frequency and "Md" for the median. We

find that in the small schools the median in almost all instances hovers around 21 correct responses for the boys and 13 for the girls, with about 17 for all. In other words, it is quite evident that the work of the girls in the small schools is quite far below that of the boys. Of course, we must take into consideration the small number involved. In the large schools the tendency is to be around 24 for the boys, 19 for the girls, and 22 for boys and girls together. The difference between the scores for the boys and girls is not so great for the large as for the small schools. In considering all the pupils in both types of schools we find that the median for the boys is in the neighborhood of 24, for the girls, 18, and for all of them, 22. The only science whose median exceeds that of all the pupils is botany, but it is only by one point and so is insignificant. Scores made in general science are practically the same as those made by all pupils. Consequently, so far as the data of Table II are concerned, we find that in doing this particular physics test previous knowledge gained from the study of other sciences does not help to produce a better score. In fact, a more interesting piece of information is that obtained from comparing rows 8 and 9. We find in every instance, so far as the boys are concerned, that the median score of those who have previously studied no science is at least one point greater than for those who have studied one or more sciences. The median in all schools for both boys and girls for those who have had no science and those who have studied one or more sciences is almost identical.

Another interesting fact to be deduced from the original information which forms the basis of Table II is that the distribution of scores is almost normal with just a slight tendency of skewness to the left. That is, the test is just a trifle more difficult than it is easy. The range in scores for those who had had no science was for boys from 35 items to 6; for girls, from 32 to 5; for those boys who had one or more sciences, from 38 to 6, and for girls from 34 to 6. This means that for all 302 pupils the range is from 38 items correctly answered down to 6 for boys, and 34 to 5 for girls, and from 38 to 5 for both boys and girls. One interesting feature of the top scores is that the highest score made by a boy, namely, 38, and one of the two next highest scores made by boys, namely, 37, and one of the two highest scores made by a girl, namely, 34, were made by three of the eleven pupils in the physics class of Wawaka high school.

An interesting side issue in an analysis of the test was the occurrence of multiple scores made on various items. Out of 56 people who made multiple responses to the number of 200, 15 made 5 or more each of these. The most outstanding cases of multiple responses are those of two pupils, one of whom made 16 out of a possible 40, and the other, 15 out of 40, double or triple answers. Since the directions called specifically for writing in the number of one, and one only, principle, it is interesting to wonder just what type of mind an individual has who does this kind of thing. Evidently, he does not read directions well. The boy who made 16 multiple responses had a score of 12; the boy with 15 multiple responses, a score of 6; one with 12, a score of 18;

and one with 11, a score of 12. These were all boys. It is rather evident that a person who makes so many multiple responses is either bluffing or is a doubting Thomas. Such cases should receive special investigation, a thing which is, of course, not the purpose of this study.

The question arose as to the extent to which schools whose pupils had not studied Sound answered the ten principles under Sound, items 3, 5, 7, 11, 15, 19, 21, 26, 28, and 40. A rather rough comparison was made as to the number of correct and incorrect responses made by the two groups on these two items. We shall call the schools in which Sound had been studied group S, and those in which Sound had not been studied group N.S. On item 3 the S group had more correct responses than incorrect; the N.S. group twice as many wrongs as rights. On item 5 the S group had 3 times as many wrong as right; the N.S. almost 5 times as many. For item 7, the S group was evenly divided between correct and incorrect responses; so was the N.S. group. In item 11 group S had twice as many incorrect responses as correct; the N.S. group, 3 times as many. For item 15 the S group had twice as many correct as incorrect; the N.S. group was almost even. In item 19 group S had 3 times as many errors as correct responses; the N.S., 4 times. For item 21 group S had twice as many errors as correct responses; the N.S. group 5 times. For item 26 the S group had twice as many errors as correct responses; the N.S. over 3 times. For item 28 the S group had twice as many correct as incorrect; the N.S. half again as many correct responses as incorrect. For item 40 the S group had half again as many correct as incorrect responses; and the N.S. group a third again as many correct as incorrect responses. We find from this part of the investigation that those schools which had not studied Sound did not do as well as those that had studied Sound, but why they did as well as they did is a problem that has not yet been attacked. In the analysis of the errors made in selecting the various fields for explanations there was uniformity between the two groups only on items 3, 7, 11, and 19. In all the other cases except item 40 the N.S. group had chosen for explanation one more field than had the S group. In item 40 the S group had chosen one more field than the N.S. group.

The data on college students show that there were 38 out of the 86 who had had no physics in high school or college. These people made a median score of 12. Of the 34 who had had high school physics only, the median score was 17.5. There were only two who had had college physics only, with a median of 15.5, while the median scores of the 12 who had had both high school and college physics was 30. With the exception of the last group we find that the scores of the college group fall far below those in high school. The conclusion which seems to be warranted is that immediacy must play a considerable part in the ability to answer this particular test.

The following are some rather tentative conclusions to be offered:

1. It is rather early to state just what it is that this particular test measures. Anyone who has ever tried to construct a test with certain very definite purposes in mind will realize that the results of

the test not only bring out things which the test-maker had not anticipated, but also make it doubtful as to whether the test really measures what it purports to measure. Such a statement may be made in regard to the present test. One of the purposes is to find out whether or not it would be possible to devise a test which would show us the extent to which the laboratory-manual type of physics taught in high school gives the pupil an ability, if you will so allow me to call it, to recognize what relationship may exist between physics studied and such applications as we can find about us in everyday life. Certainly the results of the test do show that by no means do the 300 high-school pupils in the schools in which this test was given make the proper connections between principles and applications when half of the items are answered correctly with a frequency of 168 and less.

2. Girls almost invariably make lower scores than do the boys.

3. The median scores seem to show that it makes no difference in the taking of this test whether or not a pupil has studied some other science previous to his studying physics.

4. That immediacy plays a prominent part in the taking of the test is evidenced in the fact that university students who have had high-school physics make on the whole a much lower score than do the high-school pupils.

5. There is a possibility that college students might be able to explain in their own language the physics involved in the various items, but that, when confronted with the technical names of the principles, they are unable to establish the proper bonds and so resort to a great deal of guess work.

6. That the test is fairly reliable is indicated by the high score made by those who have had physics both in high school and in college, and that there is a very high degree of conformity to the answers that had been determined upon before the test was given.

7. Pupils who had not studied Sound did not do as well on the 10 Sound items as did those who had previously studied the subject. This was to be expected. The strange thing was how in some schools, particularly the larger ones, there were many pupils who made a rather fair showing in this section.

8. Large schools, so far as their totals are concerned, unquestionably make better applications than the pupils in the small schools. The boys do about the same in both instances. It is the girls who make the differences. A possible explanation is that girls in the larger city schools work in better equipped laboratories and come into contact with more applications of physics; or it may be that they are not permitted to enter physics classes unless they are of the better type of students. No one of these suggestions is stated dogmatically. Any one or all of them may explain the situation.

9. Much of the physics taught in high school, from textbook examinations, shows that the teacher emphasizes the thing that we have in this investigation called principles.

10. If one of the purposes of the secondary school curriculum is to relate the subject-matter taught in school to applications of this

subject-matter found in occurrences of everyday life, and since the results of this experiment seem to show that such a transfer is rather questionable, does it not behoove the teachers of science, physics and others, to organize the content of the field so that it becomes more meaningful to the boys and girls who study it? Much of the science that we teach in high school is lip service. Pupils are able to repeat in the words of the text certain laws or principles when asked, but when it comes their turn to relate these laws or principles to many of the things which are happening about them every day, they are at a loss to see any connection.

11. The test has, of course, certain weaknesses of which the chief one, it seems to us, is that it is questionable how many of the 40 items that have been included are really practical applications. Just by way of illustration, how many individuals have occasion to break a jug full of water by pressing in the stopper? How many have had anything to do with cream-separators, or how many have seen inverted glass bottle water-coolers? Likewise, how many have ever sailed a sail-boat or seen one that reacts according to the principle of the resolution of forces? I hope that you will recognize, of course, that there is nothing final about a test of this sort, that any test, no matter how constructed, will show up certain peculiarities in the way people react to the questions put before them. But when we do find a preponderance of evidence of so-called errors then it becomes time for us to sit up and take notice, and seek methods of improvement, provided, of course, that our thesis that subject-matter in high school should always bear some practical relationship to life as we live it, is tenable.

In conclusion, I wish to state that much of the work in carrying on this investigation is due to the help given by the members of my seminar, Mr. J. R. Shannon, Mr. R. T. Wyckoff, and Mr. W. H. Kinsey. Without their assistance the experiment could not have been conducted. I wish thus to express to them my appreciation of their assistance.

Social Psychology as a Basis for Educational Psychology

CHARLES H. JUDD, Professor and Head of the Department of Education, University of Chicago

Since the days of Herbart, a century ago, educators have recognized the fact that a scientific organization of instruction in the schools must be based on psychological principles. Herbart pointed out with unmistakable clearness the necessity of studying the minds and progressive development of pupils. He also pointed out that there must be a study of human social relations if the goals of education are to be properly defined. He held that ethics is equally important with psychology as a basis of sound educational practice. Herbart's injunction that education be based on ethics as well as on psychology has not been heeded in most teacher-training institutions. The recognition of the importance of psychology has been so universal that it is the common practice in normal schools and colleges of education to introduce students to the study of education by requiring them to take a course in psychology. Ethics is, on the other hand, seldom offered and when offered it is usually an elective in the last year of the teacher-training curriculum.

Herbart's contention that education must be based on ethics can be translated into modern terminology somewhat more adequately if one substitutes the term "sociology" or the term "social psychology" for the term "ethics." Herbart meant to call attention to the fact that the intellectual development of pupils does not depend solely on the impulses that come from within but is controlled and should be consciously directed by considerations which arise from the pupil's relations with his fellow-beings.

There is very great need at the present time for a careful examination of the tendencies in modern education in the light of the double demand which Herbart expressed when he based education on the two foundation sciences, psychology and ethics. There can be very little doubt in the mind of anyone who studies the history of psychology and of education since the time of Herbart that the individual has been always and constantly considered in the development of educational theory and practice, while society and its larger demands have been pushed into the background.

It is natural that the science of psychology should concern itself first of all with individuals. The sense organs of the individual and his reactions to sensory stimulations are concrete and tangible facts. Measurement of impressions and responses is possible, and it is comparatively easy to infer from direct observations the kind of internal organization which is being developed in the nervous system of the individual thru his experiences. Psychology has been predominantly a

science of individual mental life. Where groups of individuals have been studied, emphasis has usually been laid on the differences which are exhibited by various members of the group. That there is anything in the way of group consciousness has seemed to be only vaguely in the thinking of scientific students of mental life. Psychology has been able to experiment with individual memory and with individual imagination. Social memory and social reconstruction of ideas have not been thought of except in a remote and nebulous way.

The strong natural trend in psychology toward the exclusive consideration of individuals has been powerfully reinforced by the spirit of modern times. Everywhere in our day the individual is asserting demand for freedom. We like to think of personal initiative as one of the highest virtues. We arrange our school programs so that the individual may make progress at his own natural rate. We can find no more impressive criticism of practice in school and in society outside of the school than to say it is handed down by tradition. There never was a time when thinking was more individualistic than it is at the present time.

Certainly it is not the intention of this paper to overlook the great contributions which individual psychology has made to education. The psychology of habit is a most helpful and illuminating body of material. The teacher who watches a pupil acquire skill in handwriting and follows the gradual development of the intricate muscular coördinations which are involved in this performance is greatly helped in the performance of his or her duty as a guide of the pupil's maturing powers by reading the chapter by James on the nature of habit. The teacher of drawing who notes the gradual development of discrimination from the first stage where the child sees only vaguely the space characteristics of objects to the later refinements of artistic perception is greatly helped by reading a chapter in the psychology of space perception. The teacher learns from psychology that imagination is the basis of understanding of geography and history. He learns also from psychology what are the elements of literary appreciation and what is the character of the abstract thinking which is involved in the study of science and mathematics. Psychology of individual mental processes is an indispensable basis of educational theory.

Without overlooking the contributions of individual psychology, it is the purpose of this paper to make as clear a case as possible for the neglected branch of science which Herbart called ethics. I can express my own views somewhat better if I am allowed to amend somewhat Herbart's terminology and possibly even his doctrine. I think of ethics and sociology and all of the other sciences which deal with human nature as branches or subdivisions of social psychology. I shall paraphrase Herbart therefore by saying that the science of education must base itself on individual psychology and social psychology.

The contention which I am trying to present in favor of social psychology does not seem difficult to justify when one thinks of the fact that all education is an effort to pass on to the oncoming generations the accumulated intellectual possessions of the race.

Even before the child enters school he has had the advantage of the experience of countless generations who formulated the language in which he expresses his simple needs. He is surrounded by the appliances of civilization which are the products of mechanical skill that no single individual could possibly have cultivated without the example and guidance of earlier workers. The child is surrounded by protective influences which have become institutionalized and fixed thru long racial experience, such as the family, property rights, and respect for life and liberty.

As soon as the child enters the school he has the advantages which come from a carefully prepared environment where books and pictures and maps and paper and pencils are provided so that he may acquire with a maximum of celerity and a minimum of effort all that the race has learned in its long effort to master the physical world and in its effort to arrange human relations so that there shall be as little friction between individuals as possible.

The difference between the products of human effort such as language and the institutions which safeguard life and property, on the one hand, and the objects of nature, on the other hand, is that the products of human effort have a character which can truly be described as psychological. Thus, language as it is transmitted to the child is seen to have a psychological character since words which compose the vernacular represent acts of intellectual discrimination. When an object is named or when a verb which expresses an act is coined the word which results is not a mere sound; it is an expression of a human discrimination; it is an embodied idea. The discrimination and the idea were important enough for human life to lead some human being to coin the word as a means of marking off this particular experience from all others. Thus when the word "plant" is spoken, the very existence of the word shows that it is important for human experience that plants be distinguished from animals and from inanimate objects. When the verb "walk" is used, the word shows that it has been and is important in human life to distinguish between walking and running, between walking and standing still, between walking and flying. Words are expressions of discriminations performed by human intelligence.

Furthermore, since words do not become established as part of a language until many people use them, we may be sure that all established words represent discriminations which have been often repeated and are of more than transient value. Words are not like physical objects, independent of human interests; words are psychological in their character.

What has been said about words can be repeated in slightly modified form for such products of human effort as result from civilized industry. When a man makes anything, be it a tool or an article of ornament, that object is not like a natural object. The article made by human hands is an expression of some human need. The tool is a device for making human action more powerful and more effective. The string of beads which is worn for ornament makes its appeal to human interest in color and form and has value because it satisfied a human de-

sire. Thruout the history of the human race it has been possible to draw a sharp line between natural objects and objects fashioned by the skill of man. It makes no difference what is the material employed in the things that are touched by human skill; the products of such skill gain their value from the changes which human effort has imposed on the raw material.

The distinction between an object of nature and what I have been calling a psychological object or one which is dependent on some form of human skill is a distinction of major importance to education. Let me illustrate by a simple case. I hear a sound. My first impulse is to locate the source of the sound. If I find that the sound comes from an animal or a waterfall or the wind or a slamming door, I am usually satisfied. If there is something unusual about the sound my curiosity may carry me further and I may look for the remoter source of the movement which produced the sound. Most of the sounds which I trace to natural objects and their movements do not excite any extended curiosity and do not lead me to make my efforts at imitation. A natural sound is significant chiefly as a clue to the presence of the thing which caused the sound. A sound produced by a human being has a totally different significance. In the first place, such a sound is likely to be within the possibility of imitation by the listener. When one hears a human sound there is an impulse to imitate or to answer. The distant halloo of a companion stirs up in one a totally different attitude from the crash of a falling body. The halloo is a human sound. All animals are peculiarly sensitive to the sounds made by their own kind. Human beings are affected by human noises in a unique way. Not only is there an impulse to imitate or answer a human sound, but there is a kind of curiosity which extends far beyond the mere desire to locate the source of the sound. There is a curiosity of sympathy. The human sound always seems to be freighted with meaning. The sound means satisfaction or distress or surprise or welcome. The sound made by a human being is a symptom of an inner condition, and no human listener remains indifferent to the psychological significance of the sound.

What is true of sounds is true also of the objects which are produced by human skill. The moment there comes into the hand of an explorer an object which bears the marks of artizanship, however crude, there arises at once an interest and curiosity in the human purpose of the fabricated thing which is wholly different from the interest which one has in a natural object. If one has found an Indian arrowhead in the field and felt the thrill of human contact with fellow-beings even tho they are only distantly related to our present civilization, one realizes the difference between an arrowhead and a stone. The finder of the arrowhead is stimulated to go thru a train of imagined experiences which are wholly different in their character from any train of ideas excited by a natural object. We express this difference by saying that the arrowhead is a romantic object, suggesting wars and the hunt, bringing up recollections of adventure and of human experiences of an age that is gone but always captivating to the imagination.

In short, we may say as the conclusion of our discussion of these

concrete cases that whatever has human relations has a value for other human beings which no object of nature can possess.

Civilization and the educative process by which civilization is passed on from generation to generation thus become distinguished from the natural physical world which is the stage on which civilization is enacted. After all, human life is a life of human sympathies and human adjustments far more than it is a life of natural reactions.

There has been a marked tendency in recent psychology to omit all consideration of the distinction which I have been discussing. One gets the impression from much recent psychological literature that mental life consists in a series of impressions and reactions which are all of like value. Some writers have gone so far as to state quite explicitly that the reactions of men and animals are all of exactly the same pattern. There is no place in the thinking of these writers for the distinction between reactions to natural objects and reaction to psychological objects.

The effort has been made in recent times to develop systems of psychology on the theory that all reactions of all animals including man are nothing but elaborated native forms of behavior or of instincts as they are called. I never read the educational psychologies which recount in laborious detail the natural instincts of human beings without wondering how one who is concerned with schools can be so absorbed in the animal side of human nature. It is certainly true that a hungry human being will seek food. It is certainly true that an unarmed human being who sees a bear coming toward him will be afraid and run. It is certainly true that a human being who is attacked will become angry or even enraged and will fight. The interesting question is, who among us has recently been really hungry or frightened by bears or drawn into a fight? Civilization has made the native impulses of the individual as inappropriate as would be an exhibition of one's native nakedness. Civilization has banished bears and done what it can to make personal combat unnecessary.

The psychology which finds in natural instincts the pattern on which to base its prescriptions as to how to teach reading and handwriting and arithmetic is a psychology which confuses issues intolerably.

The fact is that when one looks closely at the educational psychologies which have magnified the instincts one finds that there is a huge gap between the descriptions of instincts given in the first chapter and the treatment of the school subjects assayed in the later chapters. Indeed the gap is so wide that sometimes the writers of instinct psychologies never arrive at the school subjects. One looks in vain for a chapter on language in these books. It would seem from these treatises as tho language were some form of remote and artificial performance quite unknown to the teacher. Handwriting would seem to be a modified instinct of grasping, but the emphasis in the psychology seems to be on grasping while the effort of the school is directed to the cultivation of the art of penmanship which is what it is just because it is not grasping.

I am not interested, however, chiefly in a critical attack on the educational psychologies which have neglected to adopt the methods

of social psychology. I am interested rather in convincing you, if possible, that a study of social psychology will illuminate the way in education. Let us consider in some detail the example which I have suggested, namely handwriting.

Handwriting is not an instinctive form of behavior. It is not practiced by primitive peoples. It uses highly perfected artificial materials such as paper and pens and ink which are not present in nature and consequently could not incite the forms of reaction which are transmitted thru heredity. The various different kinds of handwriting practiced by different nationalities are further evidence that this art is a result of human endeavor during recent periods, not a natural native gift.

Penmanship as an art is related on the one side to the discrimination of spatial forms and on the other to the controlled execution by the muscles of the hand of certain very complicated forms of reaction. The interesting point is that while writing requires a very high power of spatial discrimination and a very perfect motor coördination, it is frequently related to a total inability to draw, which is also an art requiring spatial discrimination and muscular coördination. We have here a situation which seems to be full of contradictions. Let us see whether our social psychology will help us in solving the apparent anomaly.

In the early history of writing there was no trace of the distinction which is exhibited today between drawing and writing. Anthropology and the history of primitive civilizations tell us that the earliest written records were series of pictures. The pictures were crude and did not represent the object to which they referred at all completely. The earliest hieroglyphics were mere outline sketches of men and beasts and of objects. These crude sketches could be read by anyone who knew the objects and had wit enough to follow the relations so as to piece together the narrative told by the train of pictures. Even at this stage there is something quite artificial about the art of making human records. Apparently only a few of the members of a tribe were disposed to draw the crude sketches. Perhaps the instruments necessary to trace the lines were hard to construct and to manage. Be that as it may, the main fact is that whatever there was of writing was identical with whatever there was of drawing.

From this point on, history shows us that a separation took place. The separation was not sudden, to be sure, but it has resulted ultimately in a wide bridge between drawing and writing. Man lavished on certain objects a detailed discrimination of spatial characteristics. Man learned to draw the deer that furnished him food. He cultivated ability to represent this interesting animal with all of its minutest characteristics depicted with complete fidelity. Again, man became interested in the beauty of the human form and gave heed to each line and feature. Long afterwards man learned to draw trees and landscapes. In all these discriminations of details man perfected himself until ultimately he was skilful in drawing. Graphic art came to that mature stage which we know today.

It is important for our purpose to note that this highly evolved

power of discrimination was cultivated only by the few. Most of us are even in these latter days content with the rough crude sketches which marked the limits of graphic art for primitive man.

While graphic art was being perfected by a slow process of evolution, another line of evolution was being followed, again by a chosen few. This second line of evolution originated in primitive picture drawing but did not go in the direction of perfection of spatial detail. The second line of evolution moved toward extreme simplification of the figures which were used in making records. It moved in the direction of writing. The figures employed in writing became in due time so sketchy and simple that they lost their direct association with the outlines of objects and took on a wholly artificial association with the spoken names of these objects. It took long generations to accomplish this evolution of what we now call the alphabet; and again, as in the case of graphic art, the evolution carried with it at first only a few of the members of the tribe.

Thus social psychology teaches us how two arts were evolved. Starting from the same root these two arts grew in wholly different directions. Like remote branches of a tree or like two paths branching from the same fork, graphic art and the alphabet separated farther and farther from one another until the relationship between the two is not now readily recognizable.

That branch of the evolving arts which we know as the alphabet has two interesting characteristics. One is the characteristic already mentioned of being very highly simplified in its spatial outlines. The second is the characteristic which is described in the statement that the symbols which make up the alphabet are standardized and recur again and again in exactly the same forms.

One sees in these characteristics of the alphabet the reason why training in the recognition of the forms of the letters of the alphabet gives no training in general attention to space forms. Indeed, he who becomes most expert in recognizing standardized letters of the alphabet is by that very training drawn away from the miscellaneous study of objects in general. We find therefore that graphic art and the alphabet are not only different from each other but in their final stages they are directly antagonistic. The study of graphic art makes the learner keen to discriminate spatial characteristics and relations; the study of the alphabet is a highly circumscribed specialty. In the mastery of the alphabet attention is fastened to a few objects and is withdrawn from general spatial discrimination.

Something quite analogous has happened on the motor side. The artist who draws has been obliged to cultivate a nicety of reaction, and a delicacy of touch and movement which make it possible for him to follow sympathetically a great variety of outlines.

He who forms the letters of the alphabet has also developed certain delicate adjustments of the hand, but the purpose of his training has not been to make him master of sympathetic imitation of various fluctuating delicate outlines. The maker of letters must execute movements that are precise and standardized. The maker of letters is in these

modern days a man who is in haste. His drawings have been cast in a form which permits transitions from letter to letter with the least possible obstruction of movement.

While social evolution has been perfecting and differentiating drawing and the alphabet, another important process has been going forward. Society has found that the kind of record which can be made by using the alphabet is so much more general, so much more flexible, and so much more expressive of essential relations than is graphic art, that the alphabet has been accorded the highest place among the devices of communication, while the graphic arts have been forced into the position of a limited device for directing attention to certain specific characteristics of objects and to a few crucial relationships.

The wide social significance of the alphabet coupled with its highly conventionalized form and the simplicity of the outlines which it employs has led us in this modern stage of human evolution to take a most extraordinary step. We have issued the social edict that every individual in the social world shall acquire as early as possible the power of producing and using the standardized alphabet. In order to aid the individual in acquiescing in this social demand, we have supplied him with perfected physical instruments, we have set aside for his training a time and place, and we have delegated a selected member of society to see to it that he does what society wants him to do. We literally force on the individuals a highly perfected scheme of expression and we brook no refusals.

The process by which we carry out the drastic prescriptions of society and the results on the individual are highly interesting to the psychologist. The psychologist sees in handwriting a perfected system of expression which the individual is capable of mastering because the system was devised by human beings. The psychologist sees the individual saved the long process of invention by which the alphabet came into being. The individual is introduced to a complete and finished psychological product. This is in one sense a great economy. On the other hand, the individual is deprived of any of the contacts which a natural evolution would have provided. The very perfection of the system prevents it from serving as a training of the individual in general spatial discrimination. Children do not learn to look at trees and animals and men with insight into details of form when they learn the alphabet. The alphabet is a collection of specialized forms. Training in space discrimination is specific and limited.

On the motor side also training is very specific. A highly perfected writing tool prepared for one and only one type of manipulation is put into the child's hand and he is told to achieve with the greatest possible celerity the kind of muscular behavior which is required for the management of that tool.

Can anyone consider such facts as we have been reviewing and think of education as a purely natural process? Can anyone think of education as a maturing of the instinct? Can anyone think of educational theory as concerned solely with the individual's nervous system and with the laws of habit formation in the individual?

In selecting handwriting as the example which illustrates the importance of social psychology for the student of education, I choose what I believe to be the simplest case of social control of individual development. Reading is also a highly perfected art. The use of number is, as I have pointed out in an earlier paper, a highly artificial and abstract method of dealing with the world.

Handwriting and reading and arithmetic are perfected outcomes of human evolution forced suddenly and insistently on pupils who would not naturally arrive at the point of cultivating these forms of experience if they were left to their individual devices.

If students of education are to understand their problem, they will have to understand the systems of experience to which pupils are being introduced as well as the particular difficulties which pupils encounter when they try rapidly to obey the dictates of society and acquire forms of experience and modes of behavior which are only very remotely natural.

It is my firm conviction that the science of education has gone far astray in its devotion to a one-sided and inadequate psychology, the psychology of the individual, and that the next line of progress and one which we should hasten to follow is in the direction of a more adequate account of school operations thru a study of social psychology. Both individual psychology and social psychology are essential to a complete understanding of the educational process. Emphasis needs to be placed in our day on social psychology.